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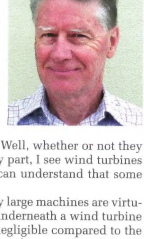
Publisher's Letter

Wind farms are a blight for people in their vicinity



Last month, I wrote about how wind power is not a substitute for base-load power generation. And while there may be fairly wide agreement with that argument, there is another aspect of wind power which has rarely been discussed: the effect of wind farms on people who live close by.

In the past, I have not understood the vociferous opposition of some communities to wind farms. They claim that they are a blight on the landscape or that they are a hazard to birds or they object to the noise they make. Well, whether or not they are a blight on the landscape is fairly subjective. For my part, I see wind turbines as graceful machines spinning slowly in unison but I can understand that some people would prefer the original unaltered landscape.

But noise? Why would noise be a problem? These very large machines are virtually silent, aren't they? Years ago, I stood immediately underneath a wind turbine as it was operating and concluded that any noise was negligible compared to the noise of the wind itself. And most acoustical consultants have produced pretty much the same conclusion: noise is negligible.

It turns out that if you live in the vicinity of a wind farms, noise is most certainly a problem – a really big problem! While wind turbines actually produce very little audible noise they do produce infrasonic noise, ie, noise in the range 0-20Hz and it is this noise which affects people who live nearby – they simply cannot escape it. And while you may think that the noise of the wind itself would drown out the whooshing noise of the wind turbine's blades and any infrasonic effects, that is not the case. You can have the situation where a house some distance from a wind farm is experiencing calm conditions or it may be upwind but the noise of a nearby wind farm can be clearly heard, or in the case of infrasonic noise, felt.

Now while acoustical consultants may be of the opinion that low-level infrasonic noise is innocuous, doctors and the people immediately affected can attest otherwise. People complain of nausea, headaches, dizziness, lack of sleep and so on. Now nausea and lack of sleep I can identify with. At night, if you are having difficulty sleeping, you tend on focus on low-level sounds which are barely noticeable during the day. And if you can physically perceive the noise of wind turbines during the daytime, the effects are bound to be worse at night.

But the worst aspect of this noise is the realisation that it is never going to stop. That noise will always be there – for the rest of your life! You are trapped! Nor can you make the decision to sell your house and move away. Word gets around and values for properties within several kilometres of wind-farms rapidly fall to a small fraction of their value before the turbines were installed.

I can barely imagine the feelings of those people who are badly affected by this noise. It is a life sentence where no crime has been committed! I suppose you could invest in double-glazing and sound proofing to ameliorate the effects while you are inside your home – but why should you be forced into this situation which is entirely out of your control? And while sound-proofing might be a solution when you are inside your home, it will be no help when you are outdoors.

It also turns out that wind turbines can produce visible flicker effects that people find disturbing. You can imagine that this could well be the case when the sun hits the moving blades from some angles.

What to do? First, any Authority charged with the approval of proposed wind farms must take the noise and other effects seriously. There needs to be consideration of compensation for any property owners within several kilometres of the development.

But those people who are already seriously affected are the ones who are really in a bind. Already there a quite a few people in Australia who are blighted. Their concerns must be addressed. Not to do so would be unconscionable.

Leo Simpson

MAILBAG

Letters and emails should contain complete name, address and daytime phone number. Letters to the Editor are submitted on the condition that Silicon Chip Publications Pty Ltd may edit and has the right to reproduce in electronic form and communicate these letters. This also applies to submissions to "Ask SILICON CHIP" and "Circuit Notebook".

National Broadband Network deja vu

With regard to the Publisher's Letter in the November 2009 edition, concerning the proposed National Broadband Network, I despair that government fails to either acknowledge the expectations of those they are supposed to represent nor learn from past, bitter experience.

Here we have the advantage of 20-20 hindsight following the cable roll-out in the 1990s, yet government sails on heedlessly. The arrogance is simply astounding. Government anti-Telstra prejudice is more than obvious, yet Telstra is more than ably equipped, materially and technologically, to deliver a sensible solution. We, the mute many, are led by the monumentally uninformed few. What are we to do?

Gary Broughton,
Renmark, SA.

Many motorcycles do have ignition advance

I wish to comment with respect to your response to A. T. of Mount Gambier (Ask SILICON CHIP, December 2009) that "Most motorcycles do not have ignition advance . . .".

This is incorrect. Many motorcycles have at least RPM-related advance and many modern injected bikes have load and throttle position related advance as well. RPM advance is used for the same reason that it is used in cars, to compensate for the change in time that the piston takes to move a given distance with varying RPM and the relationship of this to the more constant time required for the fuel mixture to burn and generate maximum cylinder pressure after ignition.

David Boyes,
Canberra, ACT.

Accuracy of mains frequency-derived time

Your letter from PC in the December 2009 issue regarding clocks referenced to the mains was of interest to me. Before retirement, I worked for National Grid in the UK and at one stage in my career I was responsible for maintaining "frequency time" monitoring equipment.

Although the UK National Grid runs at a nominal 50Hz, this varies continually in response to normal supply/demand imbalances, so is usually in the range 49.7Hz to 50.3Hz, although the deviations might be larger than this in the event of an emergency trip on a large generator or sudden loss of a large load block. The typical result of these variations is that the "frequency time" can be several seconds slow or fast if measured over any 24-hour period.

To compensate for this, "Target Frequency" instructions are periodically issued to all power stations on the grid, either 50.05Hz to gain time or 49.95Hz to lose time. These target frequencies are then used to bias the steam turbine governors away from their normal 50Hz setting.

This all sounds straightforward until you consider the method of tracking the mains frequency to determine the time error. It is no good tracking the frequency at just one location, as this becomes a single point of failure – so measurements at multiple dispersed geographical locations are needed. These frequencies are sent via landline telemetry back to the UK National Control Centre.

Even this arrangement has pitfalls. In the event of a telemetry failure from one location, several seconds can be lost during the changeover to telemetry from an alternative location. In addition, under severe fault conditions such as in the UK hurricane of 1987, the normally unified grid system can be split into two or more "power islands", which are then no longer synchronised with each other. Such splits can last for hours until the grid control engineers manage to re-synchronise the islands, during which period each island will typically have a larger than normal loss or gain of frequency time.

So if one island gains 30 seconds and its neighbour loses 30 seconds before re-synchronisation, how do you reconcile the two? In theory you could run

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Mailbag: continued

Gas power station could provide desalination energy requirements

The January 2010 Publisher's Letter sets out the facts of our government's spin doctoring in regard to the power supply for desalination plants. Sure, the wind generators can supply the energy requirement (MWh) for the desal plants over a year but would make no difference to the extra generation (or loss of reserve capacity) required to supply the desal plant (MW) as that has to be available continuously.

As one of my lecturers from the past once remarked "the amount of work you can do (read MWh) is almost infinite – it is your rate of working (read MW) that is important".

If extra generation is required, a nuclear reactor might be a bit over the odds as the power required is only about 150MW and this is easily handled by one or more gas-turbine generators located somewhere in the system. What amuses me is the fuss made over, say, 150 MW for the desal plant when increases for other reasons in the demand on the power system don't seem to matter.

I would wager that the increase in demand due to new housing and the ongoing installation of air-conditioners in existing houses would be far greater than the desal plant's requirements.

Apparently it's OK to install air-conditioners but providing a water supply not dependent on rainfall is not.

Alex Brown,
Ashburton, Vic.

Masthead amplifier article has errors

I was disappointed at such a backward-looking article on the Simple Masthead Amplifier in the November 2009 issue. It is out of touch with some aspects of digital TV reception.

The reason for the 0.68Ω resistor in the power pack is to prevent the transformer from catching fire if the output is short circuited. Why didn't the project use a 12V DC plugpack? Lots of antennas appear as DC short circuits if the amplifier is bypassed.

The article ignores the fact that all Australian analog TV broadcasts will cease within four years, starting in the first half of next year. Your comments about the 0-10 network are about 40 years old. Channel 0 was dropped because of the inability to remove ghosted signals, sensitivity to interference (particularly from trams) and the size of the antennas.

Whilst channel 0 has been removed from capital cites, the Darling Downs in Queensland and Eastern Riverina, NSW, still have high-powered channel 0 analog transmitters. Narooma, Tamworth City and Cooma have low-powered analog transmitters.

each island at a different 'Target Frequency' before re-synchronisation to equalise the system time errors but in practice this would take too long. The number one priority in such emergencies is to get the grid system back into one piece as soon as possible.

The result of these constraints is that whilst frequency time is usually accurate to within a second or so over any 24-hour period, there is no means of maintaining long term accuracy.

From experience, I would estimate that the UK National Grid gains or loses up to a minute in any 3-year period. This is as good as most quartz watches and good enough for electromechanical street light timers, central heating controllers and tariff time switches but not suitable as an accurate time reference.

Keith Bryan Cusson,
Mount Dandenong, Vic.

DAB+ mobile reception requires better receivers

In the Mailbag pages of the December 2009 issue, Alan Hughes has pointed out that DAB+ dead spots such as Martin Place will be minimised when the much hoped for fill-in transmitters for capital cities finally materialise. Those extra co-channel transmitters should certainly help but will it help minimise dropouts for reception in moving vehicles?

It seems to me that because digital reception typically incurs a digitisation delay of about one second, dropouts are extremely annoying. Compare this with analog FM reception at similar wavelengths and locations when all that you hear is a very brief swish.

Way back in the early days of DAB (and digital TV) in UK, I was originally impressed by the talk of multi-path reception being catered for. But how, or is, mobile reception catered for? I have yet to receive any blogs about mobile reception as experienced in the UK where multiple co-channel transmitters are presumably employed.

My own reception trials in the car were good apart from the total loss of audio for a second or two following each dropout. This occurred when receiving DAB+ commercial stations allegedly operating on full power and within 15km line of sight from the transmitters on Mt Dandenong. It also occurs when walking near to a fixed receiver inside my home.

Perhaps Alan can explain how car owners will be catered for in future or will the listeners of classical music have to be provided for by the retention of a couple of FM services in parallel with the great extra facilities provided by the myriads of DAB+ channels?

Brian Tideman,
Mulgrave, Vic.

Alan Hughes comments: The ABC/SBS Melbourne transmitter has only been at full power for a short time. The Government and commercial DAB+ transmitters have a radiated power of 50kW each whereas ABC FM is 100kW. The power of DAB+ has been limited to prevent interference to analog TV channels 9 & 10.

All DAB+ transmitters use vertical polarisation so it is essential that the receiving antenna is vertical. You will not have to rotate the antenna as you move around. This is not true of FM transmissions which are mixed polarisation. You can get DAB+ radios with an antenna input. These should be connected by coaxial cable to a band 3 (TV channels 6-12) Yagi-Uda antenna mounted on its side for vertical polarisation.

DVB-T is used for TV here and in the UK as well as DAB+ and DAB

The problem we have now is that existing analog antennas for metropolitan capitals and a few regional areas are still designed for channels below channel 6 as well as some not being designed for channels 11 & 12. This was pointed out in the reference you gave to my articles in March 2008.

As far as new digital antennas for metropolitan areas' main transmitters are concerned, they will pick up all stations except ABC1 analog with a stronger more interference-free signal.

The amplifier module should have a PC-mounted "F" socket as these connectors are the standard for digital TV. The saddle clamp used will not fit quad-shielded RG6 cable which is recommended for digital TV.

The module also needs an input bandpass filter. It should pass only 174-230MHz and 519-820MHz. Broadband amplifiers can overload on interference, which then intermodulates the interference onto the digital signal, causing unreliable reception.

Alan Hughes,
Hamersley, WA.

which are all digital systems. They give "perfect" reception, break-up or nothing. The DVB-T system assumes a stationary antenna, whereas DAB+ assumes a moving antenna. As a result there is lots of error correction performed in a DAB+ receiver to keep errors out during noise or reflected and delayed signals.

As you have noticed, the error correction requires around two seconds

Australian Digital TV Frequencies

Band 3		Band 4		Band 5	
Channel	Centre Frequency MHz	Channel	Centre Frequency MHz	Channel	Centre Frequency MHz
6	177.5	27	522.5	40	613.5
7	184.5	28	529.5	41	620.5
8	191.5	29	536.5	42	627.5
9	198.5	30	543.5	43	634.5
9A	205.5	31	550.5	44	641.5
10	212.5	32	557.5	45	648.5
11	219.5	33	564.5	46	655.5
12	226.5	34	571.5	47	662.5
		35	578.5	48	669.5
		36	585.5	49	676.5
		37	592.5	50	683.5
		38	599.5	51	690.5
		39	606.5	52	697.5
				53	704.5
				54	711.5
				55	718.5
				56	725.5
				57	732.5
				58	539.5
				59	746.5
				60	753.5
				61	760.5
				62	767.5
				63	774.5
				64	781.5
				65	788.5
				66	795.5
				67	802.5
				68	809.5
				69	814.5

Countries that have completed the analog switch-off have auctioned off the 700MHz band to mobile phone and WiFi companies. The 700MHz band covers Australian channels 52-69.

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Mailbag: continued

Detecting a dodgy diode

Working on problem solving a circuit recently I tracked the frustrating fault to a "dodgy" small signal diode. The diode turned out to be a normal zener diode! Apart from a conventional black cathode stripe, this "standard" clear glass zener diode had no markings, numbering or other differences to distinguish it from others in my large collection of diodes cannibalised from circuit boards over the years – and don't we all have them? I thought it was time to test them all.

Checking the back issues of SILICON CHIP, I noted John Clarke's simple 9V Battery Tester in the Circuit Notebook section of the April 2008 issue. With some modifications, a general-purpose Zener Tester could be breadboarded in a flash, using a variable-voltage power supply, a high-intensity red LED and substituting the 1kΩ current limiting resistor with a 2.2kΩ replacement. The zener diode in John's circuit was then replaced by test clips and my entire diode collection was tested. I was amazed to discover that about 10% of my diodes were in fact zeners of various useful voltages.

Connecting a digital voltmeter across the test clips and cranking the supply voltage up to maximum – about 45V in my case – enabled the zener voltage to be read off in a flash. The circuit also picked up the occasional shorted diode as well (by simple reversal of the leads and/or a 0V reading), a Vf of 0.7V being normal. Maybe it's time for readers to check their collections?

Colin O'Donnell,
Adelaide SA.

Comment: a very effective zener diode tester for DMMs was published in the February 1996 issue. This runs from a 9V battery and will test all 400mW and 1W zeners from 2.2V to 100V.

of signal to be stored to allow it to operate. Hence, when the errors are too high the signal is muted for the period of the high errors plus two seconds.

If you listen to the same program on FM and DAB+ you will hear the decoding delay caused by the need to store the signal to get enough error correction data to perform error correction. The decoders are designed to freeze the direction information and to fade the sound so that you don't hear the terrible noises some DVB-T receivers make as they drop below the threshold. After the poor reception is over the decoder must store the new fresh good data. This problem afflicts all digital receivers. The only way to stop this problem is to ensure that the signal does not fall below the threshold.

DAB+ and DRM+ are designed to work with single-frequency networks. Commercial Broadcasting Australia and the ABC/SBS are yet to install any SFNs. As with Digital TV, in Single Frequency Networks all transmitters have their centre frequency made identical through the use of a common GPS reference. The time it takes for the program to go from the studio output to each transmitter input is measured. The programs are then delayed to match the longest delay.

This will mean that when the signal strengths are near equal, the signals will be virtually time-coincident because the location should be central between the two transmitters. If it is not, then the relative delays can be adjusted.

As far as cars are concerned, you need to use a radio designed for cars. This is because the RF stage will be capable of a wider range of signal strength. I have heard very good reports of the "Pure Highway" which has a choice of a stick-on antenna or a plug-in magnetic antenna. It also receives FM stereo.

The real solution to the car problem is to get the car manufacturers to install car radios designed for digital reception. This will mean a permanent quarter wavelength antenna can be mounted on the car. Digital Radio

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Capacitor Leakage Meter should have a warning panel

The Capacitor Leakage Meter in the December 2009 issue is a good design, as all your projects usually are. But I feel there should have been a warning panel in your article and on the front panel of the meter itself advising the user to carefully check that the "Voltage" setting does not exceed the voltage rating of the capacitor under test.

Also the polarity should be correct. Say, for example, a 25V electrolytic capacitor is connected and the tester is set at 100V or the capacitor is connected the wrong way around, it will most likely explode and possibly cause injury to the user.

Also another issue is that a sizeable electrolytic capacitor charged to 100V can deliver a nasty electric shock.

Geoff Coppa,
Toormina, NSW.

Comment: your comment about capacitors charged to 100V is certainly valid. However, as with all electronic equipment, it is really up to the user to apply some common sense, as for example, in selecting the test voltage to suit the capacitor's rating and making sure that an electrolytic is connected with correct polarity. However, even if a capacitor's rating is severely exceeded by the Tester (say a 16V capacitor connected to 100V), it is highly unlikely to explode or cause any injury. The Tester has been deliberately designed with this factor in mind so that the test current is limited to 9.9mA, as stated in the text.

Hence, if you connected a capacity with reverse polarity, its reverse current could not exceed 9.9mA and the amount of power dissipated within it would be very small. A worse case would be where you had a low-voltage capacitor connected to the 100V test. Again, the internal power dissipation in the capacitor is unlikely to be more than a few watts and while it might get warm and might even swell up a bit, it won't explode.

Australia has been trying to get the car manufacturers to install digital receivers in cars. It turns out that it takes four years for the car manufacturers to include a new feature into a car production line. Try driving around with the car radio and compare the results with a portable radio in the car with the telescopic antenna pulled up!

All new cars in France will be required to have DMB/DAB+/DAB receivers installed in 2014 and the UK will follow a year later. This will mean that a better antenna will be used than for a portable radio as is used now.

With the size of Australia there is a good case to add DRM30 and DRM+ to all digital radios. This will be reviewed by the government in 2011.

Alan Hughes,
Hamersley, WA.

Cut-off frequency of cascaded filters

John Yelland ("Active Filter With 2-Pole Sections" Mailbag, page 9, December, 2009) is quite correct; cascading two 2-pole high or low-pass filters will indeed give a different cut-off frequency.

The reason is quite simple: the cut-off frequency of a filter is defined as that frequency where the response is 3dB down.

At this frequency, with a 3dB drop in each filter stage, the signal with two stages will be 6dB down. This frequency does not meet the definition of "cut-off frequency" of the composite filter. So by definition, the cut-off of the cascaded filters will be at the frequency where the total drop is 3dB, that is 1.5dB in each section.

For low-pass filters, this will be at a considerably lower frequency than the cut-off of each stage considered separately; for high-pass filters, it will be at a higher frequency. It is possible to build active high and low-pass filters with up to seven poles in a single stage, although they do tend to be very "touchy".

I have, however, seen mass-produced communications equipment that used 5-pole filters in a single stage, which required only one of the resistive elements to be varied for stability.

Greg Mayman,
Dover Gardens, SA.

Comment: the reply to John Yelland

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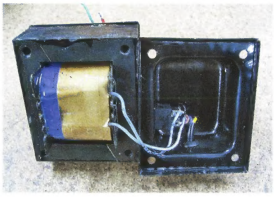
Mailbag: continued

Deadly transformers on eBay

I want to draw readers' attention to a potentially fatal "stepdown" transformer being sold in Australia that is actually an unearthed autotransformer. You can see from the accompanying photos that the primary leads are blue and the secondaries are green. This results in a lot of possibilities for mis-wiring.



In this case, the incoming Active has been wired to what should have been the Neutral side of the primary. Hence, the fuse in the secondary side is not in the output Active. Note that the unit had a 3-pin plug but the earth lead is clipped off and has never been connected. Note also that it has no approval makings, despite being sold in Australia (on eBay) by a Victoria-based business.

In our scenario, the transformer was fitted to a piece of equipment from the USA where it is common for the Neutral to be tied to chassis in the device – so when the transformer was wired up with what was supposed to be the (fused) Active lead connected to the machine Active and the Neutral to machine Neutral (and therefore chassis) we ended up with a live chassis!

The equipment had been in use for a few years with a proper isolating transformer and hence was fine. We contacted the seller but they didn't seem to understand what we were trying to explain!

Tim Stockman,
Burra, SA.

was specifically concerning the Multi-Function Active Filter rather than a general answer concerning cascading of filters.

With regard to cascading two filters, the Multi-Function Active Filter circuit is specifically using two identical 2-pole Butterworth filters where the -3dB point of each filter on its own is the rolloff. For its application as a crossover filter, cascading two 2-pole Butterworth filters gives what is called the Butterworth squared response or L-R (Linkwitz Riley) response. The -6dB point becomes the crossover frequency rather than the -3dB point.

So for general filters, cascading does affect the cut-off frequency because the rolloff is steeper. The inquiry made by John Yelland was specifically concerned with the active filter that used the two cascaded Butterworth filters. He was pointing out that the cascading will affect the crossover frequency. But in the case of the active filter using the two Butterworth filters cascaded as an L-R filter, the crossover frequency is not affected even though the rolloff is at -6dB.

Reader Peter Kay has also commented that there is confusion when talking about cut-off frequency when it should more correctly mean "crossover" frequency. These frequencies are

related but completely different. The cut-off frequency of a filter is always the -3dB point which is the half power frequency. The crossover frequency of a speaker network filter has to be chosen to give the flattest sum of the LP and HP filter sections. For two cascaded identical 2-pole Butterworth filters, the crossover frequency happens to be the cut-off frequency of a single 2-pole Butterworth filter.

Cheap torches

I cannot resist bargain shops and have bought numerous torches from them. The best value were 9-LED pocket-size ones costing $2, including three AAA cells. Then a bulkier rechargeable one appeared at $8. This had three very bright LEDs, a genuine lithium-ion 3.6V 40mAh battery and a wind-up AC generator with a full-wave rectifier which really recharged the battery.

Then came the "squeeze to recharge" model criticised in letters in your December 2009 and January 2010 issues. I bought the 3-LED model for $3.00 and a later version with two much brighter LEDs for $3.50. I used these for many months as convenient pocket torches.

When I dropped one onto concrete it broke open and I was surprised to find that the well-made generator and drive was not (as others have found) recharging at all. The generator produced a triangular wave of 5-6V peak-peak which should have been capable of doing so if rectified and if the switch had been wired differently.

However, I did not feel cheated. These were probably factory rejects at a ridiculously low price, costing less than the three button cells which gave them a useful service life.

Robin Stokes,
Armidale, NSW. SC

Wind power variations are a big challenge

I wish to thank Paul Miskelly for his letter on the contribution of wind farms, particularly in referring to the availability of electrical power production and demand data on the web.

I was puzzled by Paul's statement that the sum of wind production is more "noisy" than a single farm. I could not see how that could be true, so I downloaded some recent data, selecting Capital, Lake Bonney 2 and Waubra wind farms for their geographical diversity. I found that the standard deviation of output for individual wind farms is about 110% of the mean output, where for the combined farms the figure was 80% of the mean. Still, that is an unacceptably high figure.

Playing more with this data, I found that if demand (from the Public Historical Demand files) was scaled to equal wind farm output in the long term, wind provided sufficient power for 40% of half-hour periods and not enough for 60% of half-hour periods.

Another statistic I gathered from the AEMO web data is that there are 1611MW of wind farms listed, 186MW of hydro and 70MW of bagasse capacity. Rating wind at 35% and hydro and bagasse at 100% of availability (because they can be run on demand, even if the resource isn't enough to be run all year) shows that installed capacity is 69% wind, 23% hydro and 8% bagasse – there's not enough installed hydro capacity to provide load levelling for the currently installed wind capacity. I don't know if the Snowy Mountain Scheme is included in the total for hydro stations.

Paul's conclusion from this data is that wind has no significant place in power generation. Wouldn't it be more accurate to say that wind presents considerable challenges in being able to capture peak production? If we had cost-effective ways of doing that (such as water pumping or hydrogen production) then those solutions would contribute significantly to our total power budget, which includes our vehicle fleet as much as grid electrical demand.

Kevin Shackleton,
Dandaragan, WA.

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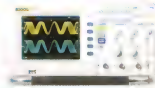

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A Look At Automotive On-Board Diagnostics

You may not know it but your late-model car has an astonishing array of sensors to make sure that its engine and electronic systems all run at peak efficiency, while keeping emissions to a minimum. This increasing use of electronics in vehicles has also lead to improvements in the way a vehicle can be maintained. With On Board Diagnostics (OBD), the performance of critical engine components can be easily monitored.

By JOHN CLARKE

ALL NEW CARS sold in Australia from 2006 onwards are required to comply with the Australian Design Rules (ADR) to include On-Board Diagnostics. This is called OBDII and the "II" indicates that this is the second generation OBD standard.

OBD is not new and has been around for more than 20 years. The first OBD standard adopted in California (USA) was introduced primarily to monitor the condition of vehicle emission sensors.

Early OBD systems included a Malfunction Indicator Light (MIL). This used a rudimentary blinking light system where the number of blinks could be counted. This blink count could be cross-referenced against a list to find the problem indicated. Over the years, there have been many refinements and improvements.

The latest OBDII standard is far more complex and includes a data link connector for connection of an OBDII scan tool which can be a dedicated hand-held unit. Alternatively, it may connect to a laptop computer via a cable that includes some form of signal processing and which is used in conjunction with special software. Either approach can be used to retrieve information from the vehicle.

On-board diagnostics are possible due to the computer systems in modern cars. Most readers would know about the car's ECU (Engine Control Unit) which is dedicated to controlling such components as fuel injectors, the exhaust gas recirculation (EGR) valves and the ignition timing. Computerised engine control is vital to ensure optimum fuel efficiency.

The ECU is not the only computer system within a vehicle. There are others that control the anti-lock braking system, stability control, cruise control, air-bag activation, climate control, central locking and even the sound system. Many of these computers communicate with each other, swapping data as required. With OBDII, communication is also available via the scan tool to provide vital information about the health of vehicle components.

A diagram showing the input sensors connecting to the ECU and controlling the injectors and ignition is shown in Fig.1. The OBDII scan tool shows a sample of the diagnostics information available when attached to the OBDII data link connector.

Modern engines are exceedingly complex, making it difficult to diagnose problems if anything goes wrong. There is an incredible array of sensors or monitors, including those for camshaft position, turbo bypass valving,

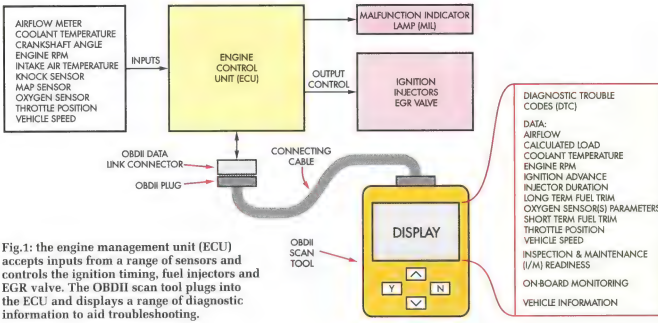

Fig.1: the engine management unit (ECU) accepts inputs from a range of sensors and controls the ignition timing, fuel injectors and EGR valve. The OBDII scan tool plugs into the ECU and displays a range of diagnostic information to aid troubleshooting.

intake and outlet valves, fuel and oil pressure, injector operation, fuel pump operation, turbo boost, ignition misfire, ignition timing, cooling fan operation, air-conditioning refrigerant, battery charging, transmission, speed, RPM and automatic transmission functions.

When there is a problem, the ECU can easily detect this because the engine sensor results will not be as expected. This is where on-board diagnostics becomes invaluable in making available the information from the ECU. Major problems are indicated with the Malfunction Indicator Lamp (MIL) or in severe cases, the lamp will flash.

As mentioned, the scan tool plugs into the ECU's Data Link Connector (DLC) which is located inside the vehicle. This connector is usually on the driver's side of the car under the dashboard, behind the ashtray, near the steering column or in the central gear-stick console area. A workshop manual will show where the connector is located if it is not easily found. For the scan tool to work, the vehicle must be OBDII-compliant and use specified communications protocols – see the section headed "OBDII Data Link Connector" for more detail.

Diagnostic trouble codes

The scan tool shows the details of any malfunctions. These are shown as Diagnostic Trouble Codes (DTCs) and are a code that can be cross-referenced against a table that describes it. Better scan tools will show both the DTC value and its definition.

DTCs are not all that can be shown by the scan tool. OBDII specifications include up to 10 modes of operation. However, not all scan tools provide for all of these and not all vehicles provide for all modes.

Apart from the Diagnostic Trouble Codes, the other modes listed in the OBDII standard include showing pending DTCs, clearing DTCs, showing a list of DTCs cleared previously, showing current (real-time) data, showing freeze frame data (data captured at the time of a DTC), test results for emissions components, control operation of on-board components and vehicle information. Manufacturers may also include additional modes.

Not all DTCs are necessarily supported or required by a particular vehicle model. Also some codes are manufacturer-specific rather than

The OBD indicator light (or engine light) appears on the dashboard display of a modern car when the ignition is first turned on. If everything is OK, it goes out a few seconds after the engine is started.

A Look At Engine Control Systems

The Engine Control Unit (ECU), as the name implies, controls the engine and it does this to provide optimum performance under all conditions. Its job is to also ensure that the exhaust emissions are as low as possible and in order for this to happen the ECU monitors various sensors. The ECU has control over fuel delivery, ignition timing and exhaust gas recirculation to meet these requirements.

Fuel is delivered to the engine using injectors that open for a certain period to meter the quantity. The ECU calculates the amount of fuel to deliver to the engine, based on various sensors. These include the volume of the air intake using a Mass Air Flow (MAF) meter or indirectly via a Manifold Absolute Pressure (MAP) sensor, the air temperature and RPM data.

Other sensors include fuel pressure and air temperature sensors, oxygen sensors to measure oxygen levels in the exhaust system, a tachometer sensor for engine RPM, a throttle position sensor (TPS) and coolant and oil temperature sensors.

For ignition timing calculations, the ECU monitors engine position, engine RPM, engine load and engine temperature. It also checks for engine knocking using a knock sensor.

Exhaust Gas Recirculation (EGR) valve control is based on engine temperature, engine load and the required emissions. It is a system that recycles some of the exhaust gas back into the engine inlet in order to reduce nitrous oxide emissions.

The engine can be run in closed-loop or open-loop mode. In open-loop operation, the ECU uses a predefined table of values for ignition timing and injector duty cycle versus engine RPM, air intake mass and engine temperature. When running open-loop, the fuel mixture will generally be rich, with the engine using more fuel than can be fully burnt in the combustion process.

Open-loop operation generally only occurs when the engine is under heavy load, such as when the vehicle is accelerating.

Under normal cruise and light throttle conditions, the engine normally runs in closed-loop mode whereby the fuel delivery is adjusted so as to maintain required air/fuel mixtures.

In general, air/fuel ratios are maintained at "stoichiometric" where there is just sufficient oxygen for the fuel to be completely burnt.

Under stoichiometric conditions, the catalytic converter can work best at converting combustion by-products to less harmful compounds. Carbon monoxide (CO) is converted to carbon dioxide (CO_2), unburnt hydrocarbons to carbon dioxide (CO_2) and water (H_2O), and nitrous oxide (NO) to nitrogen (N_2). Many cars also include a diagnostic oxygen sensor that is mounted after the catalytic converter to check efficiency.

Another benefit of the oxygen sensor is that the ECU can learn to predict the amount of fuel to provide under differing conditions. So the ECU compares the predefined table of values for injector duty cycle against the actual duty cycle required to satisfy the required mixture, as gauged by the oxygen sensor signal. The ECU then sets up a table of trim values based on this feedback from the oxygen sensor.

It can take some time for the ECU to learn the values and provide a full map of trim values. For this, it will require the engine to be run under a variety of conditions. These trim values are called "long-term fuel trim".

The ECU provides these trim values to allow the engine to run more efficiently. While driving, the engine RPM and load can change rather quickly and the oxygen sensor is not fast enough to respond to these changes. As a result, the mixture feedback to the ECU is not generic. Vehicle manufacturers may use manufacturer-specific DTC codes and imported vehicles may also use DTC codes different from generic DTC codes. We recommend that you do not fully rely on the DTC, especially for pre-2006 vehicles unless you can confirm that the generic DTC codes apply to your vehicle.

Fig.2: the OBD indicator symbol looks like a car engine. It illuminates if there is an engine malfunction.

DTC categories

DTCs are divided into four categories: "P" codes for the power train, "B" codes for body, "C" for chassis and "U" for network. P codes are the most common and include engine sensor malfunctions. These are further categorised into eight sub-sections:

(1) P0010-P0099: Fuel and Air Metering and Auxiliary Emission Controls.
(2) P0100-P0199: Fuel and Air Metering.
(3) P0200-P0299: Fuel and Air Metering (Injector Circuit).
(4) P0300-P0399: Ignition System or Misfire.
(5) P0400-P0499: Auxiliary Emissions Controls
(6) P0500-P0599: Vehicle Speed Controls and Idle Control System.
(7) P0600-P0699: Computer Output Circuit.
(8) P0700-P0899: Transmission.

The full list of power train DTCs is far too long to feature here. You can find it at **www.obd-codes.com/trouble_codes/**

Body codes include those for seat belts, lamps, solenoids, motors, ECU failure, climate control, air bags, central locking, doors, external mirrors etc. The list is at: **www.obd-codes.com/trouble_codes/obd-ii-b-body-codes.php**

Chassis codes include those for anti-skid braking (ABS) and traction control. For the full list see: **www.obd-codes.com/trouble_codes/obd-ii-c-chassis-codes.php**

fast enough for rapidly changing conditions.

However, using trim values based on past driving will have the engine run at close to the desired mixtures without waiting for the oxygen sensor response. When the oxygen sensor does respond, the ECU uses this information to make a short-term fuel trim adjustment to the current injector duty cycle. Ultimately, these short term trims are used to make up the long term fuel trim map.

For more detail on fuel trim, refer to **http://www.autoshop101.com/forms/h44.pdf**

As mentioned above, in order to understand some of the data available from a scan tool, it is important to understand how the engine works. An understanding of car electronics is also required.

The following links to teaching manuals will help. The USA branch of Toyota supplies them but most of the information is general and applies to any vehicle.

The links are grouped into separate sections and a very good coverage is made of knock, oxygen, speed, pressure, MAF, position and temperature sensors in the sensors section.

To access these, use the link **http://www.autoshop101.com/forms/hX.pdf** but replace the "X" with one of the "h numbers" listed for each category. So, for example, replace X with a number from 1-8 for one of the eight Basic Electronics manuals. For the first manual, the link is **http://www.autoshop101.com/forms/h1.pdf** and so on:

h1-h8: Basic Electronics
h12-h18: Advanced Electronics
h20-h27: Electronic Fuel Injection
h31-h38: Sensors
h39-h41: Ignition
h42-h44: Fuel
h46-h48: OBD

Table 1 above shows the full list of the teaching documents available.

Table 1: List Of Toyota Car Teaching Manuals

H1-H8: Basic Electronics
http://www.autoshop101.com/forms/h1.pdf
http://www.autoshop101.com/forms/h2.pdf
http://www.autoshop101.com/forms/h3.pdf
http://www.autoshop101.com/forms/h4.pdf
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http://www.autoshop101.com/forms/h8.pdf

H12-H18: Advanced Electronics
http://www.autoshop101.com/forms/h12.pdf
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http://www.autoshop101.com/forms/h15.pdf
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http://www.autoshop101.com/forms/h18.pdf

H20-H27: Electronic Fuel Injection
http://www.autoshop101.com/forms/h20.pdf
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http://www.autoshop101.com/forms/h26.pdf
http://www.autoshop101.com/forms/h27.pdf

H31-H38: Sensors
http://www.autoshop101.com/forms/h31.pdf
http://www.autoshop101.com/forms/h32.pdf
http://www.autoshop101.com/forms/h33.pdf
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http://www.autoshop101.com/forms/h38.pdf

H39-H41: Ignition
http://www.autoshop101.com/forms/h39.pdf
http://www.autoshop101.com/forms/h40.pdf
http://www.autoshop101.com/forms/h41.pdf

H42-H44: Fuel
http://www.autoshop101.com/forms/h42.pdf
http://www.autoshop101.com/forms/h43.pdf
http://www.autoshop101.com/forms/h44.pdf

H46-H48: OBD
http://www.autoshop101.com/forms/h46.pdf
http://www.autoshop101.com/forms/h47.pdf
http://www.autoshop101.com/forms/h48.pdf

Network codes are associated with communication between separate control modules within the vehicle or between the scan tool and the OBDII connection. For the list of these see: **www.obd-codes.com/trouble_codes/obd-ii-u-network-codes.php**

Many very basic scan tools will show trouble codes purely as the DTC value. For example, the display may show a DTC as P0130. This value would then have to be looked up to reveal the code definition. However, it is far easier to use a scan tool that also includes the DTC definition. So, for example, a scan tool that shows "P0130 Oxygen Sensor Circuit Malfunction (Bank 1 Sensor 1)" is easier to use than one that just shows the DTC value.

A scan tool should also provide the means to clear the DTC. Clearing the code removes the trouble code from the ECU and switches off the MIL.

Another way to remove DTCs is to disconnect the vehicle battery for a few seconds, to clear the ECU memory. But if a trouble code is cleared in this way, the car's audio systems will require its security code to be re-entered and the radio station presets reprogrammed. The ECU may also lose its fuel trim values (see section headed Engine Control Systems).

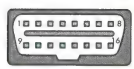
Note that a trouble code will reappear if the fault that caused the DTC has not been fixed.

Scan tools can usually show pending emission-related DTC codes. These are problems that the ECU has detected recently during the current or last completed driving cycle. They may be cleared it the ECU finds that the problem has not recurred or a pending DTC may be transferred to become a DTC. Pending DTCs are useful as an indicator for revealing if a trouble code is likely to reappear, indicating that a fault has not been fixed.

Parameter data

Apart from DTCs, being able to access parameter data is a vital aspect for locating problems. If your scan tool does not provide for this diagnostic data then you are limited in how faults can be diagnosed. Diagnostic data includes real-time data, freeze frame data and emissions tests. Diagnostic data is addressed as a Parameter IDentification (PID) value. The PID listing can be found at **http://en.wikipedia.org/wiki/OBD-II_PIDs**

The OBDII Data Link Connector



OBDII DATA LINK CONNECTOR

The OBDII Data Link Connector is shown at right. It has 16 pin locations for contacts but only a few of these will be used, depending on the communication protocol standard used by the vehicle to send data to the OBDII scan tool.

At present, there are five protocol standards. Since 2008, all new US vehicles are required to use only the Controller Area Network (CAN) protocol for OBDII communication and this standard is eventually likely to be adopted worldwide.

In Australia, any one of these five protocols may be used:

(1) CAN (Controller Area Network).
(2) ISO (International Organisation for Standardisation) 9141-2.
(3) ISO 14230 KWP2000 (Keyword Protocol).
(4) SAE (Society of Automotive Engineers) J1850 PWM (Pulse Width Modulation).
(5) SAE J1850 VPW (Variable Pulse Width).

While CAN is becoming the preferred protocol from 2008, typically the ISO protocol is used by European and Asian cars and some Dodge, Chrysler, Jeep, Ford and General Motors vehicles. VPW is also used for General Motors, Dodge, Chrysler, Jeep, Toyota and Isuzu vehicles. Ford uses PWM.

More details on these protocols is available at: **http://en.wikipedia.org/wiki/On-board_diagnostics**

Fortunately, what protocol a vehicle uses is not important because most handheld scan tools will automatically work with any of them.

For OBDII compatibility, your vehicle needs to have one of the following pin sets:
(1) CAN protocol – uses pins 5, 6, 14 & 16.
(2) ISO and KWP protocol – uses pins 5, 7, 15 (optional) & 16.

OBDII DATA LINK CONNECTOR PIN DEFINITIONS	
PIN	DEFINITION
1	Manufacturer's discretion
2	Bus(+) SAE J1850 PWM & DAE 1859 VPW
3	Manufacturer's discretion
4	Chassis Ground
5	Signal Ground
6	CAN high ISO 15765-4 & SAE J2284
7	K line of ISO 9141-2 & ISO 14230-4
8	Manufacturer's discretion
9	Manufacturer's discretion
10	Bus(–) SAE J1850 PWM only
11	Manufacturer's discretion
12	Manufacturer's discretion
13	Manufacturer's discretion
14	CAN low SAE J2284 & ISO 15765-4
15	L line of ISO 9141-2 & ISO 14230-4
16	Battery positive

(3) VWP protocol – uses pins 2, 5 & 16.
(4) PWM protocol – uses pins 2, 5, 10 & 16.

Some of the values that can be displayed in real time include airflow rate from a Mass Air Flow (MAF) sensor, absolute throttle position, calculated engine load, coolant temperature, RPM, fuel pressure, ignition timing, inlet manifold pressure, fuel trims, oxygen sensor voltages, vehicle speed, ambient air temperature and air/fuel ratio. The data is continuously updated so any output changes from each sensor can be viewed.

For some scan tools, you would have to enter the PID value and then wait for the response from the ECU to show the requested data. This can be in hexadecimal format and in a raw form that requires a formula to calculate a result. Some scan tools do this work for you and show all available data from the ECU and include the PID definitions. The data is also calculated to show the value with units such as Volts, %, °C etc, making the tool far easier to use.

Freeze frame data is the information captured by the ECU concerning the Diagnostic Trouble Code (DTC). The information shows what data the sensors were providing at the time the DTC occurred.

Emissions testing

Another worthwhile feature of the OBDII standard is emissions testing or what is called "Inspection and Maintenance (I/M) Readiness". These tests will reveal if the vehicle meets the emissions standards required when the vehicle was manufactured. The tests include monitoring of engine misfiring, fuel systems and comprehensive components (such as evaporative emission controls). These tests are made continuously.

In addition, non-continuous I/M readiness emissions monitoring are made for the Exhaust Gas Recirculation (EGR) system, oxygen sensors, catalytic converter, oxygen sensor heater, secondary air, heated catalyst and the air-conditioning system. These monitors are tested during specific drive cycles where the full extent of the sensors' operation can be checked. Testing of these will indicate a "Not Ready" status if testing is not yet complete.

On-board monitoring of sensors is also available. These provide a minimum value, a maximum value and a current value for each non-continuous monitor.

Oxygen sensors, for example, are characterised by Rich-to-Lean O_2 sensor threshold voltage, Lean-to-Rich O_2 sensor threshold voltage, Low sensor voltage threshold for switch time measurement, High sensor voltage threshold for switch time measurement, Rich-to-Lean switch time in ms, Lean-to-Rich switch time in ms, Minimum voltage for test, Maximum

voltage for test, and Time between voltage transitions in milliseconds.

Multiple oxygen sensors

OBDII-compliant vehicles will have at least two oxygen sensors. There will be one to monitor the air/fuel mixture at the exhaust manifold (the control sensor) and another to monitor gasses following the catalytic converter (the diagnostic sensor). The latter allows catalytic converter's performance to be checked.

Some engines will have more oxygen sensors, depending on how the exhaust manifolds are arranged. V6 and V8 engines will have separate control oxygen sensors for each side of the engine. Whether such an engine then has one or two diagnostic sensors depends on whether the exhaust is fed into one catalytic converter or two.

Oxygen sensors are listed according to their number and bank. Sensor 1 is associated with the cylinder 1 side of the engine, while Sensor 2 would also be used in a V6 or V8 engine (ie, another sensor in the second exhaust manifold). Bank number refers to the sensor usage. Bank 1 is the control sensor that measures air/fuel ratio at the exhaust manifold. A bank 2 sensor would be a diagnostic sensor that mounts after the catalytic converter.

Vehicle information can also be displayed using a scan tool. This shows Vehicle Identification Numbers (VIN), Calibration Identification Number (CIN) and Calibration Verification Numbers (CVN).

Using a scan tool

One point that needs to be made regarding scan tools is that the OBDII features available for that vehicle will limit what can be done with a scan tool. So a scan tool may be capable of showing freeze frame data but it will not be able to display it if the vehicle does not provide the feature.

While OBDII information appears to be complicated, when it comes to actually using a scan tool it is quite easy, especially with a good scan tool. Basically, you just plug in the lead to the OBDII data link connector located in the vehicle, switch on the ignition and wait for the scan tool to communicate with the ECU. You then select the functions you want to use, such as viewing DTCs, clearing DTCs and viewing data.

The handbook supplied with the scan tool will show how it is used.

If you want to gain some experience with a scan tool, you could force a trouble code by unplugging a sensor's connecting lead while the ignition is off. An easy sensor to locate is the Mass Air Flow (MAF) sensor, located between the air filter and the inlet manifold. A MAF sensor is used on many cars although others may have a Manifold Absolute Pressure (MAP) sensor instead.

With the MAF sensor disconnected and after starting the engine, an almost immediate pending DTC should appear and will be shown when pending codes are accessed on the scan tool. A look at real-time data for the MAF sensor will show a zero reading. If you now switch off the engine and restart, the Malfunction Indicator Lamp will probably light and a DTC may be set.

Finally, switch off the engine, reattach the MAF sensor and start the engine again. The DTC may automatically clear or you may need to clear it with the scan tool. A look at the MAF live data should now show readings

Making Your Own Scan Tool

There is a lot of information available about building your own OBDII scan tool using the ELM series of integrated circuits (ICs) to decode the OBDII protocol into a form suitable for a laptop computer. Although this is not an exhaustive list, here are some websites that may be of use in finding the data and applications for the ELM ICs and for software to run with them on the computer.

(1) The ELM series of ICs has data at **http://www.elmelectronics.com/obdic.html**

(2) For software, see **http://www.obd2crazy.com/software.html, while commercial software is at http://www.obd-ii.de/screensm2.html**

An OBDII project is available at: **http://courses.cit.cornell.edu/ee476/FinalProjects/s2009/ama64_maa66/ama64_maa66/index.html**

(3) ALDL (Assembly Line Diagnostic Link) Interface: for Holden VR, VS and VT Commodores that use the ALDL interface see **http://www.techedge.com.au/vehicle/aldl8192/8192hw.htm** For VN, VP and JE Camira see **http://www.techedge.com.au/vehicle/aldl160/vn_aldl.htm**

Note: a build-it-yourself OBDII scan tool interpreter using one of the ELM ICs is featured in this issue of SILICON CHIP.

Is OBDII Available On My Car?

Vehicles built in Australia before January 2006 do not usually have functioning OBDII. The Holden VR, VS & VT Commodores used a different system to OBD called Assembly Line Diagnostic Link (ALDL) standard. Details about this can be found in the "Making Your Own Scan Tool" panel – see above.

AU and BA Falcons and VY & VX Commodores had the OBDII connector and some OBDII functions. The BA Falcon and VY Commodore did not include DTCs but included live engine data.

The BF Falcon and the VZ Commodore do have full OBDII compliance. The FG Falcon and VE Commodore have a huge range of data available. Also, the locally built Toyota Avalon included OBDII compliance.

Imported vehicles sold before January 2006 cars may have OBDII. US-built cars such as Chrysler, built from around 1996 onwards, do have OBDII compliance. European cars from about 2000 will also have OBDII while Subarus had OBDII from 2002.

Other pre-2006 vehicles may have an OBDII-style connector or an alternative OBD connector. These tend to operate using a proprietary OBD system that is specific to either the vehicle's manufacturer or to the model. Scan tools are generally available for use with these vehicles either from the manufacturer or a scan tool supplier. For example scan tools are available for 1990 and onward VW and Audi at **www.theobd2shop.com.au**. These are called VAG (or Volkswagon AG) readers.

An extensive (but not exhaustive) check-list of pre-2006 OBDII compatible vehicles in Australia is available at **www.scangauge.com.au/support/CompatibleVehicles.shtml**

The Autel MaxScan GS500 Scan Tool

LET'S TAKE a look here at the Autel MaxScan GS500. This is a hand-held unit that weighs in at 300g and measures 95 x 180 x 35mm. A 54 x 35mm backlit LCD shows the information, while four pushbuttons provide the numerous functions.

On the top of the unit is a DB15F connector which is connected to the OBDII connector on the vehicle via a 1.4m OBDII to serial cable. A separate serial-to-USB cable is provided for upgrading the internal DTC definitions library via a computer connected to the internet.

This view shows the OBDII connector fitted to a 2005 Honda Accord. It's mounted under the dashboard, near the driver's side kick panel. The same type of connector is fitted to other late-model cars.

A padded black Nylon carry-case is also supplied to protect the OBDII scanner, its operating manual and the leads. A CD is also included, providing a library of over 8000 DTC definitions. The CD also includes a USB driver and a manual for the GS500, as well as manuals for other Autel scanners.

The GS500 works with all OBDII-compliant vehicles and supports CAN and all other OBDII communication protocols such as ISO 9141-2, ISO 14230 KWP2000, SAE J1850 PWM and SAE J1850 VPW.

Power comes via the OBDII connector. There are no internal batteries and it will not power up without connection to the OBDII port or the USB port. This is typical of scan tools.

The list of GS500 functions is numerous. These are:

(1) Read and clear generic OBDII diagnostic trouble codes, including pending trouble codes.
(2) Read and clear manufacturer-specific trouble codes, including those for GM, Ford, Chrysler, Toyota and many more.
(3) Turn off the Malfunction Indicator Lamp (MIL).
(4) Show Freeze Frame data.
(5) Display Monitor and I/M readiness status.
(6) Read live data streams.
(7) Display oxygen sensor test data.
(8) Perform Modules Present test.
(9) Retrieve Vehicle Information (VIN, CIN and CVN).

The GS500 includes real time (live) data display. This is an invaluable aid to diagnosing the cause of trouble codes. In addition, the internal trouble code definitions library is an excellent inclusion so that Diagnostic Trouble Codes are shown alongside their definition. This saves looking up a long list of trouble codes versus their definitions.

For live data, the Parameter IDentification (PID) values are shown by their definition rather than the PID number and the data is shown with units. That means that the scan tool is easy to use. Any data that cannot all be shown on the screen at the same time can be accessed by scrolling to the next screen. Alternatively, there is the option to customise what data is shown.

Operation of the scan tool to access information involves a simple 2-button up or down scroll through a menu system. An extra two buttons are used to acknowledge or exit (using Y or N buttons). Having just four buttons makes the GS500 easy

above zero that will rise in g/s (grams per second of air mass) as more throttle is applied.

In order to get the best from your scan tool, a comprehensive understanding of how a modern vehicle engine operates is required. Included here is some engine control information located in the panel headed "A Look At Engine Control Systems". We have also provided some useful tips on fault diagnosis in the following section.

Diagnosis using a scan tool

An OBDII scan tool should only be used as an aid to assist in diagnosis of a fault condition. When a Diagnostic Trouble Code (DTC) is found, it only indicates where the ECU has found a problem but not the cause. In other words, the ECU indicates the effect of the problem rather than where the problem may be.

As an example, a fault code for a MAF sensor (DTC #P0100) or MAP sensor (DTC #P0105) could just mean that there is no power to the sensor. This may be due to loss of either the ground or positive supply rail (or both) and the sensor itself may not be at fault. With this fault, probing the sensor leads with a multimeter should be done to check for power to the sensor. Continuity from the 0V supply to ground (chassis) should also be tested.

Another example is for an oxygen sensor DTC. This DTC may show as P0130 [Oxygen sensor circuit malfunction (Bank 1 Sensor 1)]. It refers to an incorrect control oxygen sensor output for a narrowband sensor.

Note that wideband sensors (as used on some late model vehicles) have a different set of Diagnostic Trouble Codes. Their output response is very different to the narrowband sensors.

The P0130 fault code means that the ECU has found that this sensor is not providing the expected output. It does not necessarily mean that the oxygen sensor is at fault and you may need to look elsewhere to locate the cause. A rash approach would be to purchase a replacement sensor only to find that this does not clear the fault.

To trace where the fault is, use the scan tool to read freeze frame data or the data stream. Freeze frame shows what the parameters were at the time the DTC occurred but this feature may not be available in your scan tool or from the OBDII in your vehicle. Real time data can show the current sensor readings but make sure you use a scan tool that can show real time data. It's a matter of setting the scan tool to monitor the oxygen sensor readings and viewing the sensor readings.

The correct output from a Zirconia-based narrowband sensor when the engine is idling is where the voltage cycles above and below a nominal 450mV. If the voltage stays well above this voltage (say >800mV), then the

The Autel MaxScan GS500 Scan Tool comes with a black carry case, a CD with over 8000 DTC definitions, a manual and connecting cables.

The GS500 works with all OBDII-compliant vehicles and has a long list of features. Power comes from the OBDII connector.

to drive and it should prove invaluable in diagnosing vehicle engine malfunctions.

The Autel MaxScan GS500 hand-held OBDII scanner can be purchased from Engine Code Readers Australia – **www.theobd2shop.com.au**

Alternative hand-held scan tools are also available from automotive suppliers such as Repco. Check that the scanner's features suit your application. See also **www.scangauge.com.au/index.html** and **www.jaycar.com.au**

mixture is rich and if the voltage stays well below (say <100mV), then the mixture is lean. These voltages are for a sensor that is in working condition.

If the voltage remains low, it could be that there is an air leak to the inlet manifold between the MAF sensor and inlet manifold. This leak will cause the mixture to be leaner than normal because the MAF is not measuring all the air entering the engine. In other words, the air leak is providing extra unmetered air that the ECU does not know about. A split in the crankcase ventilation hosing is a likely cause.

Another cause for an oxygen sensor DTC is an air leak in the exhaust manifold or oxygen sensor gasket, causing a lean reading.

If there don't appear to be any air leaks, then check the sensor's operation when it is removed from the engine. You will need to determine which leads are for the oxygen sensor element and which leads are for the heater and this can be found by referring to the vehicle's wiring diagram.

Measuring the output voltage of the sensor when under the flame of a butane blowtorch can test a narrowband sensor. Heat the tip of the sensor under the flame until it has a red glow. The output voltage should rise to >800mV due to the rich mixture and drop to <100mV when the sensor is removed from the flame. The sensor may be faulty if it does not produce any voltage.

Another scenario for the fault code may be that the sensor voltage stays at a fixed voltage. It is fairly normal for the bank 2 oxygen sensor (located at the output of the catalytic converter) to show a relatively fixed voltage of about 450mV. But a fixed voltage is not normal for a control oxygen sensor at the exhaust manifold.

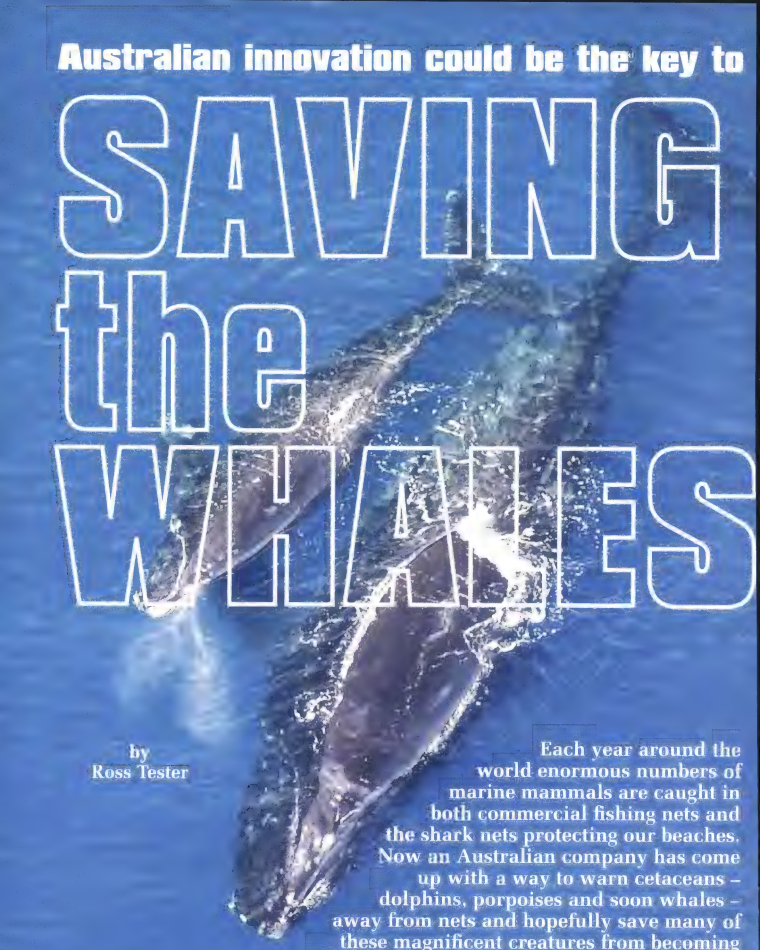
Yet another possibility is that the sensor's output voltage (as measured using an oscilloscope or multimeter) always shows a rich (>700mV) reading. For a sensor with only one signal lead, the reading would be taken between the sensor signal and the body of the sensor. The >700mV reading would suggest that the sensor is OK. Instead, the fault in this case may be that the negative (-) sensor terminal or the sensor body for the single output lead sensor is not grounded correctly.

This could be due to a wiring fault or a broken connection inside the ECU. Either way, grounding the negative (-) sensor terminal to chassis can restore sensor operation. An alternative solution would be to find the negative (-) sensor wiring for the second oxygen sensor used in the vehicle and connect the floating negative sensor terminal to that.

With a single-wire sensor, the sensor may be isolated from chassis due to corrosion on the sensor or a faulty earthing strap connection from the engine to chassis. **SC**

Australian innovation could be the key to

SAVING the WHALES



by Ross Tester

Each year around the world enormous numbers of marine mammals are caught in both commercial fishing nets and the shark nets protecting our beaches. Now an Australian company has come up with a way to warn cetaceans – dolphins, porpoises and soon whales – away from nets and hopefully save many of these magnificent creatures from becoming what is euphemistically known as "by-catch".

Commercial fishermen hate seeing whales, dolphins or porpoises entangled in their nets.

Fishermen would much rather large mammals stay away from their trawl nets. Unfortunately, the very fish they are catching often attracts such animals – and they end up as part of the catch.

Apart from the damage to the nets (and the down-time for necessary repairs and/or the cost of replacement), a significant amount of their catch can actually be eaten by the time the mammal is freed, more likely dead than alive.

World-wide, it is claimed that around 300,000 of these creatures are accidentally entangled and drowned in commercial fishing nets.

Shark nets

As far as against protective shark netting off popular beaches goes, the arguments for and against drag on, with plenty of heat on both sides.

While proponents point out the effectiveness of shark nets in saving humans from attack (for example, there hasn't been a fatal shark attack off a Sydney ocean beach since nets were first introduced in 1937, after many attacks over previous years) opponents consistently point out the numbers of "other" marine animals caught and usually killed by the nets.

Again, most of the time, it's the "emotive" marine mammals including whales, dolphins and porpoises which attract attention from both tabloid media and some of the more alarmist websites.

The Pinger

But now at least, dolphins and porpoises in particular have a guardian angel in a Sunshine Coast (Qld) company called Fumunda Marine and its cetacean warning device, commonly known as the "Pinger".

The small (46 x 152mm) and light weight (210g) Fumunda Pinger is designed to be attached to a net. It emits a 300ms pulse at 10kHz every four seconds, with a sound pressure level in water of 132dB.

This frequency was chosen for two reasons: (a) it is known that dolphins and porpoises can hear it.

More importantly, numerous independent scientific studies performed around the world over the past twenty years on different species and populations of dolphins and porpoises have shown that it has the longest track-record of any signal for reducing dolphin and porpoise by-catch.

Director of Fumunda Marine, James Turner, shows his company's "Pinger" which has been reported to reduce by-catch by 80-95%. While the model he holds is intended for dolphin and porpoise repelling on commercial fishing nets, Fumunda are currently developing a Pinger specifically intended to reduce whale entanglement in commercial fishing nets and beach shark nets.

Tests also confirm that Pingers are over 90% effective in reducing dolphin and porpoise by-catch in commercial net fishing practices.

The Pinger has undergone extensive testing at the US Navy's Transducer Evaluation Center (TRANSDEC) Underwater Facility in San Diego, California which performs research, development, preproduction and acceptance testing of underwater electro-acoustic transducers for numerous Navy and private party customers.

Inside the Pinger

While exact circuit details are a closely-guarded secret, Fumunda's James Turner has revealed that it is

A close-up of the commercial fishing Pinger, showing its tiny size relative to the hand holding it. The two electrodes seen on the body are responsible for turning the unit on when it is lowered into seawater.

controlled by a Pic micro, which sets up the various timing circuitry to initiate the short 10kHz discharge via an inductor into a piezo transducer.

The result is the characteristic "ping" (not unlike a submarine sonar) which gave the unit its name. While the unit can be heard operating in air (in fact that, in conjunction with oscilloscope waverforms, is how Fumunda's quality control ensures they are working correctly. Each is compared to a known standard to ensure it is within specification).

The whole unit is potted in resin and encased in a very strong, solid elliptical case, designed to slip through the water with minimum drag on nets.

A great deal of attention was paid to the design and manufacture of the case – instead of being moulded or cast, the cases are CNC machined from a solid rod of a special co-polymer to tolerances not much more than 1 micron.

Battery replacement

One end of the case is removable to allow the user to replace the battery (earlier devices had to be returned to the manufacturer or agent to replace the battery).

Even so, battery life is estimated at two years, based on 12 hours per day usage. The Pinger also doesn't have the disadvantage of having to be removed from the fishing or shark net to have the battery replaced – as long as it is out of the water, it can be achieved in minutes.

Because it is audible to humans, no special test gear is necessary to confirm that the Pinger is working before it goes back in the water. And when it is removed from the water, it continues to ping for about two minutes – again confirming its operation.

Operation

The Pinger only starts operating when it is immersed in seawater. That's the function of the two electrodes you can see in the above photo.

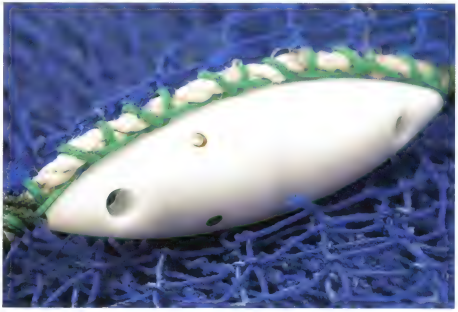
As everyone knows, sound travels significantly better through water than through air – by a factor of six times. That's why the SPL in water is a rather staggering 132dB and is also another reason why the targeted mammals can hear it so well.

Incidentally, fish, sharks and other marine animals do not have the same sense of hearing that mammals do (in fact most have none at all), so are essentially undisturbed by the Pinger – even when operating right next to them.

A significant amount of by-catch occurs at night when the nets are all but invisible in the water (during the day, they stand out much more).

What the Pinger does is acoustically "illuminate" the net. It doesn't so much say "Danger, Will Robinson" as say to the animal that there is "something" there to be wary of.

Many cetaceans navigate by eco-location. They learn that certain areas are no-go zones which hopefully will keep them safe from the nets with Pingers on them. In some ways, the Pinger operates like a fish finder, except that



This Pinger is "laced" into a commercial fishing net. The shape and material of the Pinger case makes it offer minimal resistance in the water, minimising any extra drag on the nets. Each Pinger can operate up to two years before the battery needs to be changed – a task which can be undertaken on the deck of a fishing boat quite quickly and easily.

in this case it is not looking for any echo from the fish.

Of course, while the Pinger is based on a lot of scientific studies and observation of mammal behavior, it is still based on theory.

If anecdotal evidence is any guide, the Pinger has proved to be effective in reducing by-catch. But there is obviously a long way to go and a lot more information to be gathered.

In Australia, there are around 1700 commercial fishing licences. Fumunda believe it would take around 12,000 Pingers to cover the Australian fleet. But that is just Australia, where there is no legislation forcing such devices to be used. That's a pretty significant market.

But that pales into insignificance when compared to the overseas market. It is enormous, especially now that much of Europe is widely enforces their use under the European Commission (EC) code 812/2004.

In the USA National Marine Fisheries Service (NMFS) regulations enforces the use of Pingers in certain areas of the commercial fishing industry.

The Pinger meets both of these codes and is now being sold in both areas.

Whale protection

We've concentrated on dolphins and porpoises in this feature but arguably the most public outcry occurs when a whale is caught in a net.

Various methods have been tried to keep whales away from nets in the past, including playing the sound of a killer whale underwater. But as recently as last October, a juvenile humpback whale was caught in nets off the Gold Coast while this technique was in use. Four humpbacks were caught during 2009.

However, whales are known to respond to lower-frequency signals than other cretaceans so recently Fumunda Marine started working with the Queensland Department of Primary Industries and Fisheries to reduce the number of migrating whales caught in shark nets along the east coast of Australia

Approximately 12,000 whales travel up and down the east coast each year. The team at Fumunda, like the New South Wales and Queensland Departments of Primary Industries want to reduce the number of incidental entanglements. On the west coast more than 17,000 Humpback whales make the migration to the warmer northern waters for breeding, having to navigate through thousands of lobster pots which are set everyday.

Fumunda marine believe whale Pingers could very easily be deployed in clusters of lobster pots to reduce the risk but have yet to convince the West Australian authorities.

The latest whale Pingers have been designed to operate at a much lower frequency – about 3kHz – which is known to be audible to whales. As distinct from dolphin/porpoise Pingers, the whale Pinger operates with a constant frequency tone.

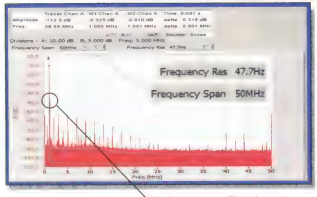
As well as being significantly smaller and lighter, making handling and fitting to the nets much easier, the new whale Pingers will also be significantly more powerful than the existing models,. They will be made using high quality internal components and long-lasting replaceable batteries, ensuring reliable performance.

The whale Pinger technology has applications globally and the company hopes to work with other stakeholders to further protect these wonderful marine mammals. SC

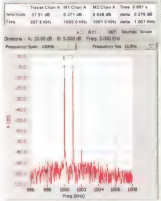
cleverscope

100 MHz MSO 8M Samples 14 bit

High Resolution Spectrum Analysis



Spectrum Graph zoom:



High Resolution Spectrum Analysis

Capture a 50Mhz bandwidth with 50 Hz resolution. Zoom on any point. Using the 14 bit ADC, you get a -85 dB noise floor over the whole bandwidth. Use the hardware moving average filter to further improve this.

Example:

Capture 1.000 and 1.001 MHz mixed signals. Display the signals with 50 Mhz bandwidth. Intermod is -80 dB!

Check out High Resolution Spectrum Analysis on the Examples page at www.cleverscope.com

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Dick Smith Lab Power Supply 0-30V 2.5A with Digital Display
Laboratory grade linear power supply with 0-30V adjustable output and an adjustable constant current setting from 0A to 2.5A at all selectable output voltages. Features separate voltage and current metering, overload protection and high/low current front panel terminals. Solidly built chassis, measures 150mm (W) x 235mm (D, inc knobs) x 145mm (H, inc feet). Not carried in all stores, but can be ordered in. Q1770

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Dick Smith 8W Battery Powered Soldering Iron
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200g Butane Gas
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Reduce soldering fumes with this compact filter. Includes a quiet, mains-powered fan, 2 activated carbon filters, adjustable stand and plastic hood assembly. T2346

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All offers on this page are for retail store stock only, with strictly limited stock available. Some items may not be available for mail orders or stock movements between stores, and back order may not be available. Enthusiast electronics items are not available in all stores; please contact your local store to determine availability.

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See and hear who is at the door before you open it! The Swann High Resolution Full Colour Video Intercom with a large 7" (177mm) LCD screen, infrared night vision, 2-way intercom and non-invasive small camera size, including user selectable doorbell tones and adjustable video brightness and contrast as well as volume control. L6191

Science Time Electrical Kits
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Build your own simple educational kits. Electronic Fan KIT53, Liquid Power Clock KIT54, Electronic Crane KIT55, Balloon Racer KIT56.

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DEKO 64pc Electronic Kit
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Highly innovative, creative and chromatic effects. Construct 3D models or spinning objects with these magnetised metal rods and nickel plated ball bearings. Mail or web-order only, not carried in stores. K1168

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VARTA
Floating Lantern with 6 Volt Battery Durable construction, long range beam, Krypton globe - includes 6 volt heavy duty battery. Y1329
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Ideal for use when your hands are not free, 3 super bright LEDs, adjustable headlight and headband, slide On/Off switch, up to 28hr run time on 3 x AAA alkaline batteries (included). Y1253
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DORCY LED Dynamo Flashlight
Simply wind handle to 'POWER UP' light, renewable energy – alternative to power light. Ideal for emergencies at home, camping and cars. No more bulbs or batteries required. Y1277
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Energizer
Energizer LED Torch with Batteries
Energizer LED torch with 55 Lumens bright light output durable strong metal casing and 2 x AA batteries included. Y1330
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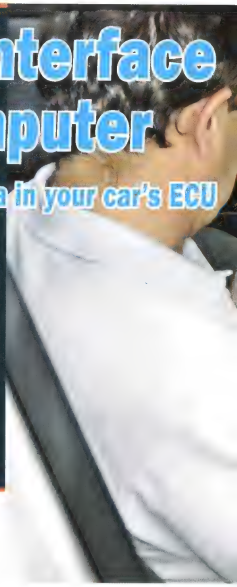
Build an OBDII interface for a laptop computer

... and read fault codes & other data in your car's ECU



If you have a laptop PC you can build your own OBDII interface so you can access all the information available to a dedicated hand-held scan tool but at a much lower cost. Not only can you access all the fault codes in your car's ECU but you can then store them in your laptop for future reference.

Design by JOHN CLARKE

ELSEWHERE IN THIS issue, we have a major feature on the topic of On-Board Diagnostics (OBDII) and here we describe how to build your own OBDII scan tool. If you are not familiar with OBDII, then you should read the feature article before reading further about this project.

Hand-held OBDII scan tools are very convenient, especially where they can be used everyday in a car workshop. However, for the home mechanic, the cost of a hand-held unit may not be justified, especially when it might only be used occasionally.

While this OBDII Interpreter does have an obvious drawback in that you must use it with a laptop computer, it does duplicate all the features available in a hand-held scan tool using freely-available software.

Alternatively, for those who have a Palm computer or a Pocket PC2002 or 2003 with a serial port, there is software available that allows these units to be used as an OBDII scan tool instead of a standard PC. We have not tried the software for the Palm or Pocket PC but we expect that it will work as claimed by the software vendors.

For the PC, there are several free software programs that are suitable for computers running Windows 98 through to Vista. We tried three of these software programs on a laptop running Windows XP with success.

The SILICON CHIP OBDII-to-RS232 Interpreter enables your laptop PC, Palm etc to operate with OBDII proto-

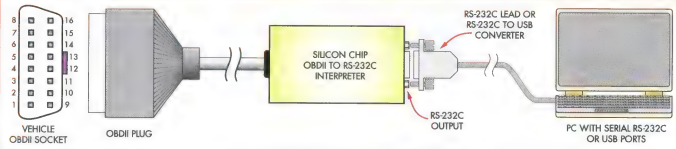


Fig.1: the OBDII-to-RS232C Interpreter is connected between the vehicle's OBDII socket and a laptop computer.

The unit is housed in a rugged metal diecast case and is powered via the vehicle's OBDII socket.

cols including CAN, ISO, KPW, PWM and VPW. The Interpreter converts the signals from OBDII format to a form suited to communication with a PC.

General arrangement

Fig.1 shows the general arrangement. The OBDII Interpreter comprises a small diecast box with a connector that plugs into the in-vehicle OBDII socket, while a DB9F connector provides an RS232 connection to the laptop computer. If only USB ports are available on the computer, then an RS232-to-USB converter cable will have to be connected to the OBDII Interpreter instead.

LEDs on the OBDII Interpreter indicate when power is on and when OBDII data and serial data is being sent or received.

The key chip inside the OBDII Interpreter is an ELM327 which is based on a PIC16F873 microcontroller (or similar). Considerable development of the software has been done by ELM Electronics, based in Canada, to ensure the chip works correctly with all currently used communication protocols.

Note that there are low-cost OBDII-to-RS232 interpreters available at various sites on the internet and these are often based on a pirated clone of the ELM327. However, many of these cloned interpreters can have erratic operation due to software bugs.

We have specified the genuine ELM327. Data for the ELM327 is avail-

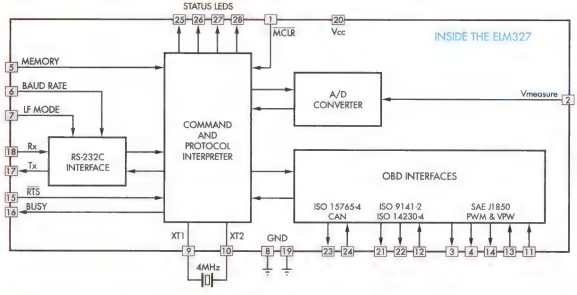


Fig.2: internal arrangement of the ELM327 IC. It's basically a custom-programmed PIC microcontroller.

able at **www.elmelectronics.com**

Fig.2 shows the internal arrangement of the device. All OBDII communication protocols are catered for so that the device will work with any vehicle that complies with the OBDII standard. These standards are CAN (Controller Area Network), ISO (International Organisation for Standardisation) 9141-2, ISO 14230 KWP2000 (Keyword Protocol), SAE (Society of Automotive Engineers) J1850 PWM (Pulse Width Modulation) and SAE J1850 VPW (Variable Pulse Width).

Circuit details

The full circuit for the OBDII Interpreter is shown in Fig.3 and is largely based on the application literature from Elm Electronics.

For the CAN protocol, IC2, an MCP2551 Controller Area Network IC from Microchip is used. Pins 6 & 7 of IC2 drive the OBDII connections for the CAN bus. IC1 sends data from its CAN Tx pin 23 to IC2 at pin 1. Data is received at the CAN Rx pin 24 from pin 4 of IC2.

A 4.7kΩ resistor at pin 8 sets the rise and fall rates on the CAN bus drive to less than 25V/µs. This slow rise and fall rate reduces electromagnetic interference.

Data for the MCP2551 is available from **www.microchip.com**

Transistors are used to provide the necessary level shifting for the other OBDII communications standards.

ISO communications use pins 15 & 7 of the OBDII connector and these are driven by transistors Q6 & Q7 from pins 22 & 21 of the ELM327. Note that 510Ω pull-up resistors are connected between each transistor collector and the +12V supply rail.

The signal from pin 7 of the OBDII connector is reduced by about 32% using a 47kΩ and 22kΩ voltage divider and is then applied to the pin 12 Schmitt trigger input of IC1. If pin 7 of the OBDII connector is at +12V, then pin 12 of the ELM327 will be at +3.83V and this is recognised as a high level.

VPW communication is via pin 2 of the OBDII connector while the PWM protocol is via pins 2 & 10. An LM317 adjustable 3-terminal regulator, REG2, sets the voltage swing at pin 2 to approximately 7.5V for the VPW protocol and 5V for the PWM protocol.

When IC1 pulls its pin 3 to 0V, the total resistance between REG2's ADJ terminal and 0V is 240Ω plus the two 240Ω resistors in parallel. This sets REG2's output to +5V. When pin 3 of IC1 is set at +5V, the output of REG2 is set to +7.5V. This is applied to pin 2 of the OBDII connector via transistor Q2 and diode D2. This occurs when transistor Q1 is switched on via pin 4 of IC1, in turn switching on transistor Q2.

Pin 10 of the OBDII connector is pulled low by transistor Q3 when it is switched on via the pin 14 output of IC1.

For PWM operation, transistors Q4 & Q5 convert the differential signals at pins 2 & 10 of the OBDII bus to a single-ended signal which is fed to pin 13 of IC1.

IC1 monitors the vehicle battery via a voltage divider comprising 47kΩ and 10kΩ resistors on pin 2 (Vmeas). It then converts the input to a digital value. This becomes part of the live data and is displayed on the computer screen.

RS232 operation

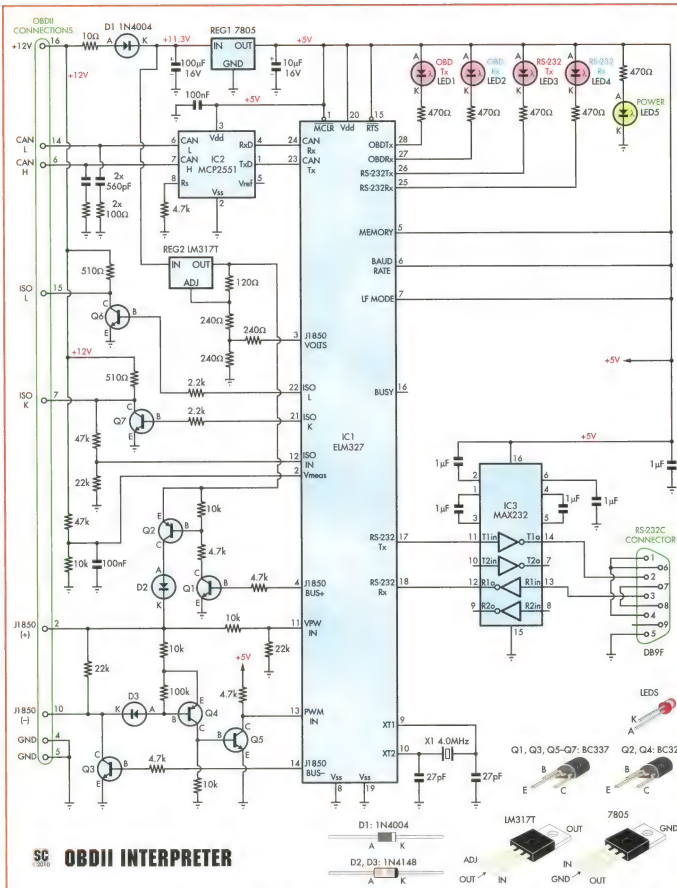
While IC1 does have RS232 (Tx) and Receive (Rx) lines for serial data at pins 17 & 18 they require translation to the standard RS232 levels. This is the task of the MAX232 RS232 driver, IC3. IC3 converts the 5V signal levels from IC1 to ±10V levels for RS232 signalling. To do this, the 5V supply to IC3 is doubled in value and also inverted using internal switching circuitry and the external 1µF capacitors.

Default settings

Pins 5, 6 & 7 of IC1 are all tied high (+5V) on the PC board to select default options. For example, pin 5 of IC1 is connected to +5V to select the memory option – it remembers the last OBDII protocol connection. So if your vehicle uses the VPW protocol for example, this will be selected when the Interpreter is used next time.

Selecting the memory option makes connection much faster. Without the memory, each protocol would have to be tested for a valid connection until successful communication was achieved.

Pin 6 is connected to +5V to set the



OBDII INTERPRETER

Fig.3: the complete circuit diagram of the OBDII-to-RS232 Interpreter. As well as the ELM327 microcontroller, it also uses an MCP2551 Controller Area Network IC (for the CAN protocol) and a MAX232 driver (IC3) for level translation.

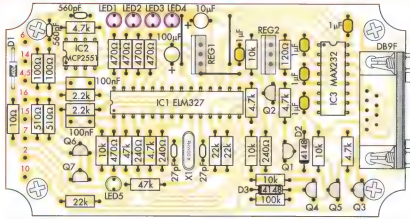
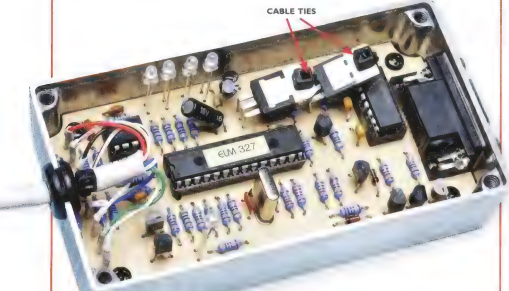


Fig.4: install the parts on the PC board as shown in this layout diagram. Note that 3-terminal regulators REG1 & REG2 and the two electrolytic capacitors have to bent over to clear the case lid (see photo below).



This is the view inside the prototype. Note the cable ties (arrowed) attached the tabs of the two 3-terminal regulators. They are necessary to prevent the metal tabs from shorting to the case lid.

RS232 baud rate to 38,400 bits/s. When pin 6 is tied to 0V, the baud rate is 9600.

With pin 7 at +5V, IC1 sends a line feed signal after each block of data as well as a carriage return. With pin 7 at 0V, only a carriage return signal is sent. You could change each of these options by cutting and linking the tracks associated with pins 5, 6 & 7 but we cannot think of why anyone would want to do so.

A 4MHz crystal connected to pins 9 & 10 of IC1 sets the frequency of operation and determines the accuracy of the baud rate and the OBDII data rate.

LEDs 1-4, connected to pins 25-28 of IC1, show RS232 and OBDII signal operation.

Power for the circuit is derived from the 12V supply from the OBDII port (pin 16) via a 10Ω resistor and reverse polarity protection diode D1. The 10Ω resistor and 100µF capacitor filter the voltage applied to the 7805 5V regulator, REG1. LED5 is the power indicator.

Construction

The SILICON CHIP OBDII Interpreter is assembled onto a PC board coded 05102101 and measuring 105 x 56mm. It is housed in a diecast box measuring 111 x 60 x 30mm. An 8-way cable provides connection to the OBDII connec-

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
1µF	1µF	1u	105
100nF	0.1µF	100n	104
560pF	NA	560p	561
27pF	NA	27p	27

Table 1: Resistor Colour Codes: OBD Interceptor

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	3	22kΩ	red red orange brown	red red black red brown
❑	5	10kΩ	brown black orange brown	brown black black red brown
❑	5	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	2	510Ω	green brown brown brown	green brown black black brown
❑	5	470Ω	yellow violet brown brown	yellow violet black black brown
❑	3	240Ω	red yellow brown brown	red yellow black black brown
❑	1	120Ω	brown red brown brown	brown red black black brown
❑	2	100Ω	brown black brown brown	brown black black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown

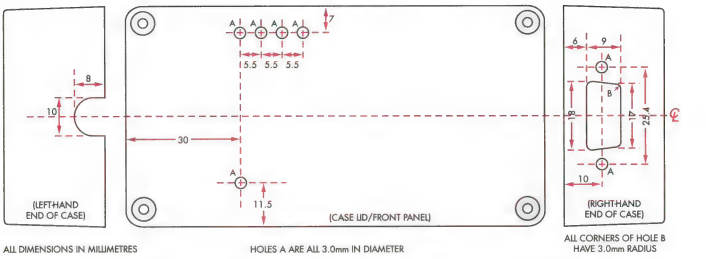


Fig.5: follow this diagram to mark out and drill the holes in the the metal case. The cutout for the RS232 socket can be made by drilling a series of small holes around the inside perimeter, then knocking out the centre piece & filing.

tor while an RS232 female connector provides connection to a computer.

Fig.4 shows the component layout for the PC board. Begin construction by checking the PC board for any defects such as shorted tracks or breaks in the copper. Check also that the corners have been shaped to clear the internal corner sections of the box. The corner cut-out shaping required is outlined using thin tracks on the underside of the PC board.

Insert the 0Ω links and the resistors first, taking care to place each in its correct place. Use the colour code table as a guide to select each resistor and check each one with a digital multimeter before installing it on the PC board. That done, solder in the PC stakes for the OBDII cable connections – see also Fig.6..

Now install the diodes and the IC sockets. For IC1, it can be difficult to obtain a DIP28 socket that is 0.3-inch wide. A 0.6-inch wide socket can be used instead but with the socket cut into two separate 14-way strips which are then mounted separately. Take care to orient the sockets correctly.

The capacitors can be installed next but be careful with the two electrolytic types – they must be oriented with the polarity shown. In addition, the latter must be bent over to clear the lid of the box.

Transistors Q1-Q7 can be mounted next, taking care to use BC337 NPN transistors for Q1, Q3, Q5, Q6 & Q7 and BC327 PNP transistors for Q2 & Q4.

Now for regulators REG1 and REG2. They must have their leads cranked so that they can clear the lid of the case. We placed a cable tie through the mounting hole of each regulator tab and secured the tie in place around the end of the tab. This ensures the metal tabs will not make contact with the metal case lid – see photo.

The LEDs are next on the list. Install each one so that its top is 21mm above the surface of the PC board. This will allow them to protrude slightly through the lid when it is in place. Take care to orient each with the anode (longer lead) toward the top of the PC board.

A cardboard spacer cut to 16mm and inserted between the leads of each LED as it is soldered into place can be used to accurately set their heights.

Finally, install the crystal and RS232 DB9F right-angle connector. Note that the mounting clips for the connector may need expanding a little on the underside of the PC board so the connector is held in place securely rather than relying on the soldered pins holding it in place.

OBDII Interpreter: Main Features

- Enables checking for diagnostic trouble codes
- Clears trouble codes and Malfuntioning Indicator Lamp (MIL)
- Shows real-time data
- Extra features are software dependent
- Interpreter interfaces between the vehicle's OBDII port and a computer
- Serial or USB connection (via an adaptor) to computer
- Power for the OBDII Interpreter obtained via the vehicle's OBDII port
- Works with CAN, ISO, KPW, PWM and VPW protocols

Boxing it

The first step here is to mark and cut out the shape required for the DB9F connector in the side of the case. All the relevant dimensions are shown in Fig.5.

The cut-out can be made by drilling a series of holes around the inside of the marked perimeter and then knocking out the centre section. Use a file to finish the job.

A semicircular cut-out is needed at the opposite end of the case to accept the cord grommet. The grommet is ultimately secured in place with the lid.

Next, unscrew the two spacers on the DB9F connector and insert the PC board into the box. That done, mark out the corner mounting holes in the base of the box, then remove the PC board and drill these out to 3mm. These holes are then countersunk

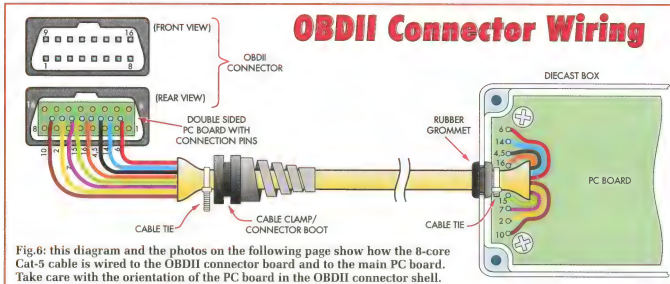


Fig.6: this diagram and the photos on the following page show how the 8-core Cat-5 cable is wired to the OBDII connector board and to the main PC board. Take care with the orientation of the PC board in the OBDII connector shell.

from the underside of the box to suit countersunk screws.

Finally, five holes must also drilled in the lid of the case for the LEDs.

Once the drilling has been completed, the PC board can be mounted in the case. Begin by attaching the 6mm spacers to the underside of the PC board using M3 x 4mm screws, then insert the board into the box and secure with it using countersunk screws through the bottom. The DB9F spacers can then be screwed onto the connector to secure it to the box.

Cable wiring

To wire up the OBDII connector you will need a 600mm length of 8-core Cat-5 cable. The details of the cable wiring are shown in Fig.6. **Note, however, that the wire colours shown are not what you would find inside a real Cat.5 cable. We've used the colours shown in Fig.6 for clarity**.

First, strip the outer sheath back by about 30mm at each end and then strip the insulation off each wire, prior to soldering. At the PC board end, pass the lead through a grommet and fit a small cable tie over it to act as a cord clamp. That done, fit heatshrink sleeving over each of the eight wires before soldering them to the eight PC stakes on the board.

At the OBDII connector end, pass the cable through the stress-relief/cord clamp before soldering the wires to the small double-side PC board of the OBDII connector. This board comes with 16 pins already fitted which connect to eight PC pads in between the two rows of pins.

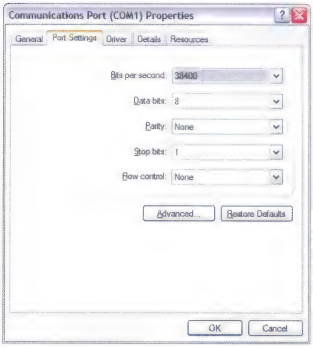


Fig.7: the COM port you will be using on the laptop must be set to 38,400 baud, 8-bit data, no parity and one stop bit. Leave the flow control setting at none. Note: this dialog is accessed through Device Manager (see text).

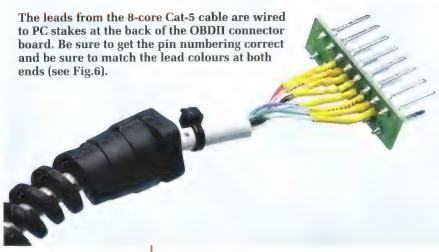
To make it easy to connect the 8-way Cat-5 cable to it, we first soldered eight PC stakes to the board. The eight wires are then soldered to the stakes. As you can see in the relevant photos, each individual wire is first fitted with a 10mm-long heatshrink sleeve before being soldered to its PC stake.

Before soldering the wires, make sure the pin labelling (1-16) on the rear of the double-sided PC board matches the pin numbers moulded into the OBDII connector housing (as seen from the front), ie, pin 1 on the rear of the double-sided PC board must match pin 1 on the inside front of the plug. Fig.6 shows the details.

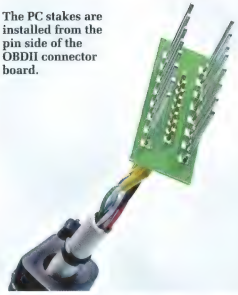
Why do we make a point of this? As supplied, our connector had the double-sided PC board with the connector pins oriented incorrectly by 180°. This can be fixed by removing the PC board/pin assembly from the OBDII connector shell and reinserting it with the correct orientation.

A cable tie around the cable will prevent it from being pulled out through the cable relief/cord clamp (we found that the cord clamp does not sufficiently anchor the cord). The wiring at the other end of the cable is simply connected to the PC board pins.

Finally, make sure that the wire colours going to the pins in the OBDII connector match those going to the PC board, as shown in Fig.6.

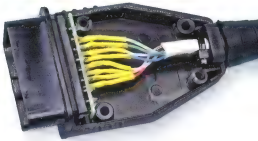


The leads from the 8-core Cat-5 cable are wired to PC stakes at the back of the OBDII connector board. Be sure to get the pin numbering correct and be sure to match the lead colours at both ends (see Fig.6).



The PC stakes are installed from the pin side of the OBDII connector board.

Another view of the wiring to the OBDII connector board. Use a cable tie to stop the lead from pulling through the cord clamp



Be sure to fit the connector shell/ keyway over the pins with the correct orientation – see text & Fig.6.

At this stage, you should be finished with the assembly, so let's discuss computer ports and software.

Computer ports

Before proceeding with the software downloads, decide what port you will be using on your computer for the OBDII Interpreter connection – ie, either an RS232 serial port or a USB port. If you have an older PC or laptop with a serial port, then this is the cheaper option as you only need a serial extension cable. However, to state the obvious, a PC is not portable and requires 230VAC power.

By contrast, if you have a laptop that doesn't have a serial port, your only option is to use a serial-to-USB cable to connect to one of the USB ports.

For serial port use, the COM port needs to be set for 38,400 baud, 8-bit data, no parity and one stop bit. To do this in Windows XP, first right-click My Computer to bring up the System Properties dialog, then click the Hardware tab and click on the Device Manager button. Now click the "+" sign next to Ports (COM & LPT), the right-click the Communications Port entry, click Properties and select the Port settings tab to bring up the dialog shown in Fig.7.

Finally, change the serial (usually COM1) port settings to the values listed above, ie, 38,400 baud, 8-bit data, no parity and one stop bit (leave the Flow Control setting at none).

Using a USB port

If you are using a USB port, then you will have to install a USB-to-serial converter driver. The CD supplied with the cable contains drivers for Windows Vista, Windows XP and Windows 98, so be sure to choose the correct driver to suit your operating system.

When you plug the USB-to-serial converter into a USB port, you will be automatically prompted to install a suitable driver from the disk. You can either manually select the driver or choose automatic installation by selecting the appropriate options.

In operation, the USB driver uses a virtual serial communications port. Depending on the operating system, you may be required to select a COM port number for the USB-to-serial converter. Be sure to select a COM port number that is free to use.

For computers without a serial port, you can usually select COM1. Conversely, for computers with a serial port, a COM port number that is different to the original COM port must be selected.

In addition, the settings for the virtual serial port will need to be checked. To do this in Windows XP, go to the Device Manager (as outlined above), click the "+" sign next to Ports (COM & LPT), right click the USB-to-serial bridge entry and change the Port Settings to 38,400 baud, 8-bit data, no parity and one stop bit.

Software packages

As mentioned earlier, we tested three software packages with the OBDII-to-RS232 Interpreter. A sum-

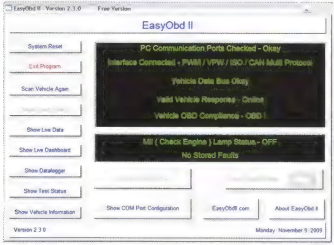


Fig.8: EasyObdII has lots of features. It works with our Interpreter but only when using a serial-to-USB converter.

Fig.9: this General Data screen grab shows just some of the information that's available using EasyObdII.

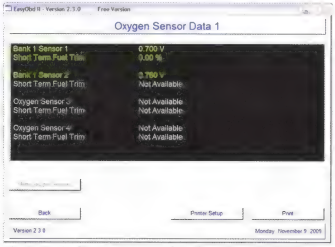


Fig.10: typical oxygen sensor data from EasyObdII. The outputs from two Bank 1 sensors are shown here.

Fig.11: EasyObdII's On Board Diagnostics Tests page shows which tests have been carried out & completed.

mary of the features available for each package is shown in Table 3.

(1) The EasyObdII v2 software covers most OBDII features and is written specifically for Scantool OBDII interfaces only. However, it does run using our OBDII Interpreter but only when using a serial-to-USB converter and a USB port on the PC. It's available free of charge from **http://www.easyobdii.com** (although you have to go through the on-line purchasing process).

After completing your details, an email will be sent informing you of the site location to download the software. The software downloads as an executable file called **EasyOBDII.exe**.

The **EasyOBDII.exe** file can be saved into a new folder called **c:\programs\Easy OBD**. Then a shortcut can be created and placed on the desktop. When run, the COM port is automatically selected and the OBDII connection is made. The port status can also be checked by clicking the **Show COM Port Configuration** button – see Fig.8.

A sample of the general data available with the Easy OBDII software can be seen in the screen grab of Fig.9. Oxygen sensor data is shown in the screen grab of Fig.10, while on-board diagnostic tests are shown in Fig.10.

(2) Werner Digital Technology at **OBD2-Crazy.com** provides free software for the ELM32X based OBDII converters. This software can be downloaded as a zipped file (FULwOBD.zip) from **http://www.obd2crazy.com/software.html**. Download the file, open it and run **setup.exe** to install the program and place a shortcut on the desktop. The version we used was wOBD v1.51.

Table 3: Summary Of OBDII Software Features

	EasyObdII v2.3.0	wOBD v1.51	ScanTool v1.15
Read DTCs*	Yes	Yes	Yes
Clear MIL* and DTCs	Yes	Yes	Yes
Real-Time Data	Yes	Yes	Yes
Continuous I/M* Monitors	Yes	Yes	-
Non-Continuous I/M Monitors	Yes	Yes	-
Vehicle Information	-	-	-
Freeze Frame Data	Yes	-	-
Serial Or USB Operation	USB only	Both	Both

*DTC = Diagnostic Trouble Code; MIL = Malfunction Indicator Lamp; I/M = Inspection & Maintenance

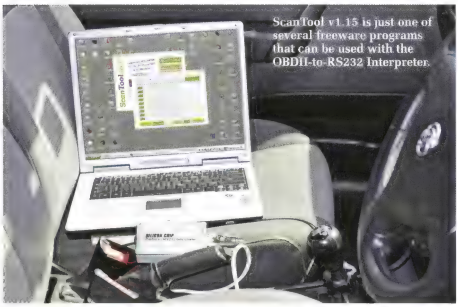
In order to use this program, both the COM port and the baud rate must first be set. It's just a matter of selecting the correct COM port number and setting the baud rate to 38,400. The screen grab of Fig.12 shows a COM4 setting and this is for a virtual serial port using a USB input on our laptop computer. This COM number may be different for your computer.

The Check Engine page of wOBD (Fig.13) shows the Diagnostic (MIL) Codes and the status of both the Continuous and Non Continuous Monitoring functions. Fig.14 (Poll Data) shows some of the data available. The white sections are the valid data while the grey sections show data that has yet to be updated. Note that some data is in imperial units (°F, psi and mph) while other data is in metric units (kPa and gm/s).

The data can be updated repetitively by setting the screen refresh update rate to 1s.

(3) The third program, ScanTool v1.15, is open source software and can be downloaded from **http://www.scantool.net/scantool/downloads/diagnostic-software/**. The download file is **scantool_net115win.exe**. This file is then run to install the ScanTool software and a shortcut is placed on the desktop.

As before, both the COM port and baud rate need to be set. The port is



ScanTool v1.15 is just one of several freeware programs that can be used with the OBDII-to-RS232 Interpreter.

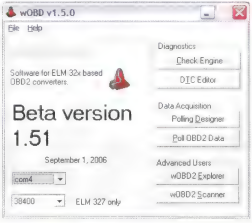


Fig.12 (left): wOBD is another excellent freeware program that works with our OBDII-to-RS232 Interpreter. A COM4 port setting is shown here (change this to suit your computer) and you must set the baud rate to 38400.

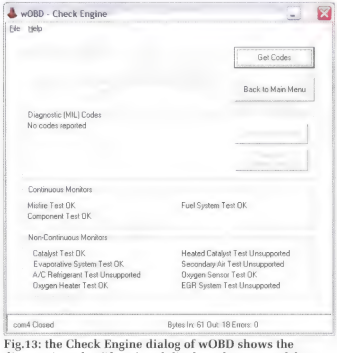


Fig.13: the Check Engine dialog of wOBD shows the diagnostic codes (if any) and displays the status of the Continuous and Non-Continuous Monitoring functions.

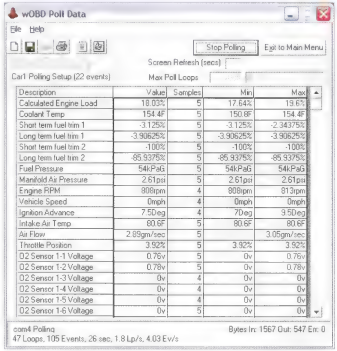


Fig.14: wOBD displays a range of data, including engine RPM, ignition advance, air flow & coolant temperature.

Parts List For OBDII Interpreter

1 PC board, code 05102101, 105 x 56mm
1 diecast box, 111 x 60 x 30mm (Jaycar HB-5062)
1 front panel label, 90 x 55mm
1 OBDII 16-pin connector (Jaycar PP-0720)
1 DB9 male to DB9 female extension cable (all pins wired straight through); OR
1 DB9 male RS232-to-USB converter cable (Jaycar XC-4834)
1 DB9F female right-angle PC mount connector
1 DIP28 IC socket with 0.3-inch spacing (or cut down a 0.6-inch socket or use two DIP14 sockets end-to-end, or use two SIL14-pin socket strips)
1 DIP16 IC socket
1 DIP8 IC socket
1 4MHz crystal (X1)
1 rubber grommet for 6mm cable
4 M3 x 6mm Nylon tapped spacers
4 M3 x 4mm screws
4 M3 x 5mm countersunk screws
1 600mm length of 8-core Cat-5 cable
4 100mm cable ties
1 200mm length of 2.5mm heatshrink tubing
16 PC stakes

Semiconductors

1 ELM327P microcontroller (28-pin slimline PDIP package); available from ELM Electronics (**www.elmelectronics.com**) (IC1)
1 MCP2551-I/P CAN IC (8-pin PDIP); available from Microchip (**www.microchip.com**) (IC2)
1 MAX232CPE multi-channel RS-232 driver/receiver (IC3)
1 7805 5V 3-terminal regulator (REG1)
1 LM317T adjustable 3-terminal regulator (REG2)
5 BC337 NPN transistors (Q1, Q3,Q5,Q6,Q7)
2 BC327 PNP transistors (Q2,Q4)
1 1N4004 1A diode (D1)
2 1N4148 diodes (D2,D3)
4 3mm red LEDs (LED1-LED4)
1 3mm high-efficiency green LED (LED5)

Capacitors

1 100µF 16V PC electrolytic
1 10µF 16V PC electrolytic
5 1µF monolithic ceramic
2 100nF monolithic ceramic
2 560pF ceramic
2 27pF ceramic

Resistors (0.25W, 1%)

1 100kΩ	5 470Ω
2 47kΩ	3 240Ω
3 22kΩ	1 120Ω
5 10kΩ	2 100Ω
5 4.7kΩ	1 10Ω
2 2.2kΩ	3 0Ω links
2 510Ω 0.5W	

selected by clicking the Options button (see Fig.15) – just select the correct COM port number and set the baud rate at 38,400. The COM4 setting shown in Fig.16 is for the virtual serial port using the USB connection on our computer. This number may be different for your computer.

Either metric or imperial units for data should be selected, depending on your preference.

A sample of some sensor data using ScanTool is shown in Fig.17. Data will not be shown unless the corresponding "ON" button is on. These buttons are toggled on or off using the mouse. If you receive the error message shown in Fig.18, the data cannot be displayed.

To restore communication, left mouse click on the OK button and the software will close. That done, unplug the OBDII connection and reload the ScanTool software. Finally, select Sensor Data and plug the OBDII connector into the OBDII socket to regain communication.

Other software

As previously mentioned, software is also available for PalmOS and the Pocket PC. This is called OBD Gauge

The unit is compact and rugged and handles all common OBDII protocols including CAN, ISO, KPW, PWM & VPW. It duplicates all the features found in commercial scan tools but uses a laptop computer for the display.

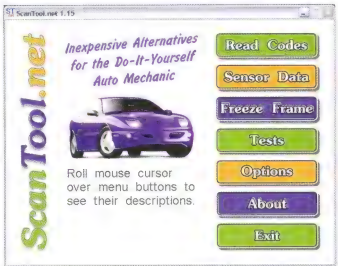


Fig.15: ScanTool v1.15 is easy to use – just click the relevant button on the opening dialog.

Fig.16: clicking the Options button lets you choose the COM port (COM4 selected here) and the baud rate (38400).

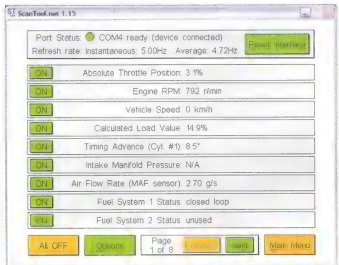


Fig.17: this screen grab shows just some of the sensor data that cab be obtained using ScanTool v1.15.

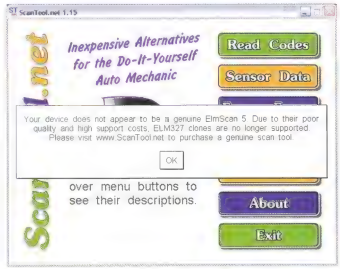


Fig.18: ScanTool v1.15 sometimes throws up this error message. Refer to the text for the way around this problem.

and can be found at: **http://www.qcontinuum.org/obdgauge/**

Conclusion

EasyObdII software is the best choice if you are connecting to the laptop via a USB port. That's because it includes most OBDII functions although as previously stated, not all functions will necessarily be provided with your vehicle.

For serial connection we liked the ScanTool software because of its impressive presentation. However, its lack of Freeze Frame data and I/M readiness monitoring makes it less attractive. Future versions of this software may include these features since the selection buttons are already there (but not yet operational).

That leaves wOBD as the best option for serial computer interface use. It only lacks vehicle information and Freeze Frame data. Whether or not lack of Freeze Frame data is a concern depends on whether your vehicle provides this feature.

Another disadvantage of the wOBD software is that it shows some data in imperial units, such as °F and miles per hour (mph). SC

An RS232-to-USB converter cable is required to connect the OBD-to-RS232 Interpreter to a laptop computer. Alternatively, you can use a serial cable to connect it to a desktop PC.

Agilent's U1732A Handheld Digital LCR Meter

Agilent Technologies has just released a new addition to its range of affordable handheld test and measuring instruments: the U1732A handheld Digital LCR meter. Designed for testing and measuring almost any kind of passive component (L, C or R) quickly, easily and accurately – on the bench or in the field, it is priced at a level much lower than Agilent's existing LCR meters.

Review by Jim Rowe

Right from Hewlett-Packard's startup in late 1938, the company founded by Bill Hewlett and Dave Packard moved into the top drawer of electronic test and measuring instrument design and manufacture. They've stayed in that top drawer ever since, with only the name changing to Agilent Technologies in 1999 when HP's T&M division split off from its computer division.

For the last 10 years they've been continuing the HP tradition of developing high performance, top quality test and measuring instruments.

But while Agilent has remained largely unchallenged in many areas of the T&M instruments market, their ongoing emphasis on high-end performance and quality did tend to price many of their instruments into the 'stratosphere' and hence beyond the reach of many hobbyists and small businesses.

At least, that was until a few years ago, when they formed a new Basic Instruments Division and started to release a range of instruments with more affordable price tags.

Things moved even further in that direction in 2008, when Agilent acquired Escort Instruments Corp of Taiwan. Escort had designed and manufactured a range of low-cost T&M instruments and as a result, Agilent was able to add the expertise of its designers to that of its existing Basic Instruments design team.

Since then, the division has been developing a range of innovative handheld instruments, which combine excellent performance with very attractive pricing – such as the U1250A series of handheld digital multimeters and the U1600A series of LCD oscilloscopes, both of which have won industry awards.

The new U1732A handheld Digital LCR Meter is the latest addition to the range. It offers many of the features of Agilent's lowest-priced LCR meter to date, the 4263B but at a fraction of the price. (The base price for the U1732A is $406, while that of the 4263B is $5858.)

Needless to say, the performance of the U1732A doesn't match that of the 4263B but all the same it's quite impressive – especially for an instrument at this price level.

And both the features and performance are likely to be more than adequate for a great many production, design and servicing situations.

For example, it provides either automatic or manual ranging for measurement of the primary parameters of inductance, capacitance and resistance presented on its main 4-1/2 digit display, plus automatic calculation of dissipation factor (DF), quality factor (Q) or phase angle (phi) which is presented on the smaller 3-digit secondary display.

It also provides a choice of making the measurements at any of four different test frequencies: 100Hz, 120Hz, 1kHz or 10kHz.

Although the U1732A is normally powered from an internal 9V alkaline battery (a plug-pack mains supply is available as an optional extra), it has built-in backlighting to improve the visibility of the LCD display in low lighting levels.

To prolong battery life the backlighting is not normally 'on' but can be turned on when needed simply by pressing one of the nine control buttons.

Another nice feature to extend battery life is automatic switching of the instrument into a low-drain 'sleep mode' if it has not been used for five minutes since the last measurement. When this occurs the U1732A's piezo sounder gives a short beep to advise you that it is 'going to sleep'.

It can be 'woken up' with its existing settings restored simply by pressing one of its control buttons. This auto power-down feature can be disabled if you wish to use the instrument for a longer period without any interruptions and is automatically disabled when it is being powered by the external power supply instead of the battery.

Further attractive features are the ability to 'calibrate' the U1732A before making a measurement on any of its measurement ranges, to compensate for the effects of any test leads or measurement jigs connected to its front panel terminals – and hence give greater measurement accuracy.

To enter this calibration mode you simply press and hold down the CAL button for over a second, whereupon the instrument indicates not only that it has entered CAL mode but also whether you should either leave the test connections open circuit (OPn) or shorted together (Srt). When you follow its directions and then press the CAL button again briefly, it performs the required compensation and then automatically switches back into normal measurement mode.

Features:

- Inductance, capacitance and resistance measurements with a choice of different test frequencies
- 20,000 counts resolution with dual display
- Auto-calculation of phase angle, dissipation factor and quality factor
- Visible and audible tolerance mode for easy capacitor sorting
- Records maximum, minimum and average readings
- Relative mode and data hold function
- PC connectivity with optional IR-USB cable

Ranges and accuracy

When it comes to basic component measurement, the U1732A provides seven ranges for measuring resistance with full-scale readings ranging from 19.999Ω up to 9.999MΩ.

The basic accuracy on most of these ranges is 0.5% of reading + 5 lsd (least significant digits), rising to 1.2% + 40 lsd on the lowest range and to 2.0% + 8 lsd on the highest range.

For capacitance there are another seven ranges, with full-scale readings ranging from 199.99pF to 50.0μF when measuring at 10kHz, or 1999.9pF to 1.000mF (yes, millifarads!) when measuring at 1kHz, or 19.999nF to 10.00mF when measuring at 100Hz or 120Hz.

The basic accuracy on most of these ranges is 0.7% of reading + 5 lsd for measurements at the lower frequencies, rising to 1.5% + 5 lsd when measuring at 10kHz. Again these figures all rise at the two measurement extremes but the specified accuracy on the 199.99pF range is still 3.0% + 8 lsd for measurements at 10kHz, while that on the 10.00mF range is still 3% + 5 lsd for measurements at 100Hz or 120Hz.

There are only six ranges for measuring inductance at 100Hz or 120Hz, with full-scale readings ranging from 19.999mH to 999.9H (henries). For measurements at 1kHz there are again six ranges but this time ranging from

1999.9µH to 99.99H (full scale readings).

For measurements at 10kHz there are only four ranges, with full scale-readings ranging from 1999.9uH to 999.9mH. The specified basic accuracy for most of these ranges is 0.7% + (Lx/10000)% + 5 lsd for measurements at 100Hz, 120Hz or 1kHz, rising to 1.5% + (Lx/10000)% + 10 lsd for measurements at 10kHz. As before these figures all rise at the measurement extremes but the specified accuracy for measurements on the 1999.9uH range is still 2.0% + (Lx/10000)% + 10 lsd at 10kHz and on the 999.9H range it is still 1.0% + (Lx/10000)% + 5 lsd for measurements at 100Hz or 120Hz.

By the way, each U1732A comes with its own Certificate of Calibration, showing that it has been calibrated against an Agilent E4980A Precision LCR Meter – with its own calibration traceable to national and international standards.

In addition to the basic measurements of resistance, capacitance and inductance, the U1732A also provides features to enhance its utility in production and lab environments. For example it can make measurements in RELative mode, where the current reading is stored as a reference value and then subsequent readings are displayed as relative values - until you press the REL button again, to return to normal measurement mode.

There's also a HOLD mode, where the current reading can be 'frozen' until you press the HOLD button again.

Then there's a TOLerence mode, which is similar to REL mode in that the U1732A stores the current reading as a reference value, then displays subsequent readings in terms of their percentage deviation from that stored value.

The TOL button can be pressed repeatedly to set the tolerance limits to ±1%, ±5%, ±10% or ±20%, to allow sorting and selection of components in a production setting. The instrument's piezo beeper beeps three times to indicate when a component is outside the specified tolerance range or once to indicate when a component is within tolerance.

As if these features were not enough, the U1732A also provides a static RE-Cording mode, where it stores MAXimum, MINimum and AVG (average) readings in memory, updating these figures as necessary. The beeper sounds each time a new reading has been recorded.

You can view these saved readings on the display at any time simply by pressing the REC button briefly, and you can also leave the static recording mode and return to normal operation simply by holding down the REC button for more than a second.

Quite an impressive list of features and functions for a surprisingly affordable LCR meter, aren't they?

By the way, I checked the current drain of the review sample U1732A shown in the photo and it gave readings of 42mA during normal operation without backlighting enabled, increasing to 55mA with backlighting. The current drain in 'sleep' mode was much lower, at only 80µA.

Optional extras

The basic U1732A LCR Meter comes with a 9V alkaline battery, a couple of short test leads (150mm overall) terminated in small insulated alligator clips, its certificate of calibration, a 16-page Quick Start Guide booklet and a Product Reference CD ROM containing a full User's and Service Guide manual (as a PDF file) as well as data-logging software for PCs.

However, in order to put the data logging software to use with the U1732A, you need to purchase one of its optional extras: the U5481A IR-to-USB adaptor cable.

This has an IR to USB converter module at one end which attaches to the rear of the U1732A case near the top, and a standard USB type A plug at the other for connecting to your PC. The U5481A IR-to-USB cable costs $41.00.

Other optional accessories for the U1732A include a soft carrying case (U1174A, $28.00), a pair of SMD component measuring tweezers (U1782A, $41.00), an AC power adaptor (U1780A, $48.00) and a set of additional alligator clip leads (U1781A, $14.00).

It's also possible to buy the soft carrying case and the SMD tweezers bundled together with the U1732A meter itself, for a bundled total price of $447.00.

I should also mention that a three-year Agilent Calibration option is also available for the U1732A, to ensure that its calibration is kept up to date. But the cost of this option is more than three times that of the U1732A itself – $1491.00, no less.

So for most of us, it would be cheaper to buy a brand-new (and therefore newly calibrated) U1732A each year.

Trying it out

I was lucky enough to get my hands on one of the first U1732A's to become available in Australia. This is the unit shown in the photo and I spent a very interesting couple of days putting it through its paces.

I was very impressed with what I found. The U1732A turned out to be quite intuitive to use and I had no problems in making measurements of a good selection of reference resistors, capacitors and inductors. I found myself particularly appreciating the CAL facility too, although you do have to bear in mind that even if the U1732A is in auto-ranging mode when you reCALibrate, it returns to normal measurement mode in manual ranging mode and in whatever measurement range it was in before CALibration.

Another little trick I discovered concerns the 'wake up from sleep mode' function. If you're operating the U1732A from its battery and haven't disabled the auto power-down function, it will put itself to sleep after five minutes even if you are proceeding to check a series of components on a particular range and test frequency.

Then, although the manual says that you can wake it up with the original settings simply by pressing any key, if you do this by pressing some of the keys you will actually wake it up in default power-up mode instead.

In fact I found that the best key to use for its wake-up call was the backlight key in the centre of the top row – this always woke it up with the original measurement settings intact.

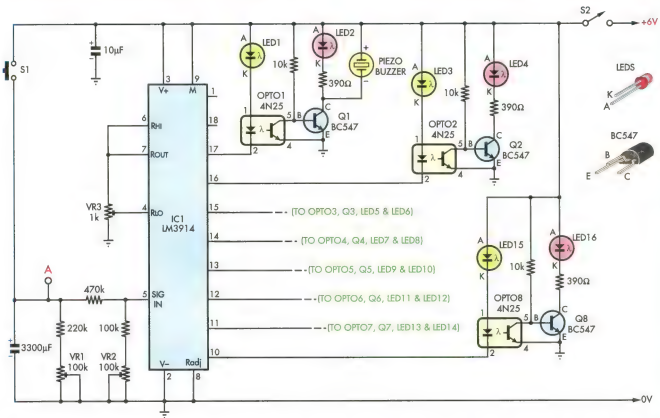
Incidentally Agilent advises the U1732A should always be turned off fully with the main on-off button when you are putting it away, ie, it should not be put away in sleep mode. That's presumably because even though the current drain in sleep mode is only 80-odd microamps, this is still enough to flatten the battery if it's left that way for many days or weeks.

I was really very impressed with the U1732A Digital LCR Meter – so impressed that I've decided to invest in one myself. Need I say more?

You can find more information on the U-1732A at Agilent's website (**www.home.agilent.com**) and also on the website of the Agilent Australian distributors, Trio SmartCal: (**www.triosmartcal.com.au**). SC

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



Shower/egg timer uses red & green LEDs

This circuit can be regarded as an electronic version of the 4-minute sandglass timers which were available some time ago. Instead of transferring sand from an upper to a lower glass bulb, this unit has two arrays of eight LEDs – a vertical column of eight green LEDs and a horizontal row of eight red LEDs, all controlled by an LM3914 bargraph display chip.

When it starts, all the green LEDs are lit and all the red LEDs are off. As it times out, the green LEDs progressively go out, starting from the top, and the red LEDs light up, starting from the left. When the last green LED goes out and the last red LED turns on, a buzzer sounds to indicate the end of the timing period.

In essence, the circuit works by monitoring the discharge of the 3300µF capacitor connected to pin 5 of IC1 via a 470kΩ resistor. To start, the capacitor is charged to the positive supply by pressing switch S1. The LM3914 operates in the conventional way as far as the green LEDs are concerned, with all LEDs alight when the voltage across the capacitor is at the maximum level.

Each green LED is connected in series with the internal LED of a 4N25 optocoupler. For example, LED15 is in series with the LED of OPTO8. Hence, when LED15 is on, OPTO8 is also on and this holds the base of Q8 low and so LED16 is off. When LED15 turns off, as the 3300µF capacitor discharges, OPTO8 turns off and this allows Q8 and red LED16 to turn on.

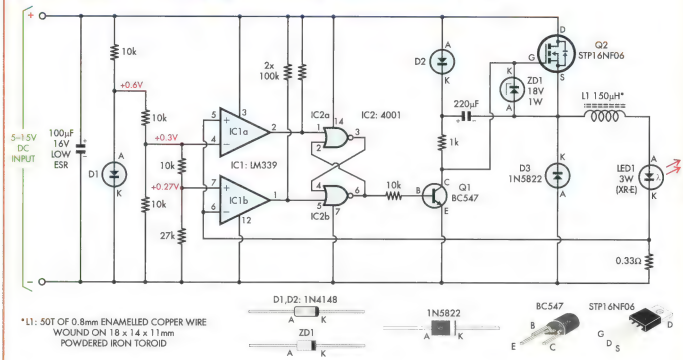
This process occurs gradually with more green LEDs turning off and more red LEDs turning on until finally, LED1 turns off and allows Q1 to turn on. This lights LED2 and also sounds the buzzer driven from the collector of Q1.

To set up the timer, first adjust trimpot VR3 until the voltage at pin 4 is 0.85V. This sets the reference voltage for the internal resistor chain within IC1. That done, disconnect the 3300µF capacitor, the 220kΩ resistor and trimpot VR2.

Now connect an adjustable power supply to the point marked "A" and set the voltage to 5.64V. This sets the level at which the highest green LED will go off. Adjust trimpot VR2 until that same LED just comes on. Thus IC1 is set to indicate between 6V and more than 4V, because only eight of the possible 10 outputs are used.

Now reconnect the capacitor, VR1, etc and press the button for a second to fully charge the capacitor. Check the time until the buzzer sounds. If necessary, adjust VR1 so that the last red LED comes on and the buzzer sounds after four minutes – or whatever time you desire.

A. J. Lowe,
Bardon, Qld. ($45)



*L1: 50T OF 0.8mm ENAMELLED COPPER WIRE WOUND ON 18 x 14 x 11mm POWDERED IRON TOROID

Switchmode LED driver

This switchmode buck converter is designed to drive a 3W LED and has a measured efficiency of approximately 80%. In effect, it is a switchmode circuit comprising MOSFET Q2, inductor L1 and fast recovery diode D3.

The switcher is controlled by op amps IC1a & IC1b. These are configured as a window comparator with threshold voltages of 0.27V and 0.3V. (Editor's note: since only two comparators are required, an LM393 could be used instead of the LM339 quad comparator).

The 0.33Ω resistor in series with the 3W LED is used to monitor the current and the voltage developed across this resistor is monitored by the window comparator. Its outputs toggle an RS flipflop comprising gates IC2a & IC2b which then drives transistor Q1 and MOSFET Q2.

The efficiency of the circuit can be maximised by using the lowest DC input voltage consistent with reliability or by driving more than one 3W LED in series.

With an input of 15V, three LEDs can be driven at about 700mA. If the output current is reduced to about 250mA, by changing the 0.33Ω sensing resistor to 1Ω, then it should be possible to drive four LEDs, although not at full output.

Note that the input voltage is limited to 15V by the absolute maximum rating of the 4001 quad 2-input NOR gate.

Before connecting an expensive LED, the circuit can be tested for maximum current by shorting the LED terminals. The voltage across the 0.33Ω resistor should be close to 0.3V. Alternatively, check the current by connecting an ammeter in place of the LED.

If you check the duty cycle at the gate of Q2, it should be close to 100% when the supply voltage just exceeds the output voltage and should then decrease with increased supply voltage. Similarly, the input current should decrease as the input voltage is increased.

Brenton Schuz,
Dudley, NSW. ($45)

Issues Getting Dog-Eared?

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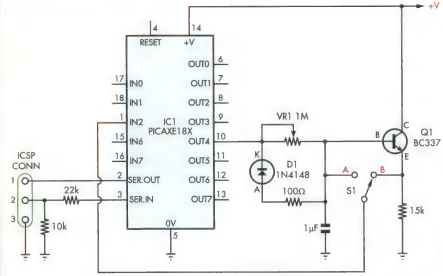


Program Listing: SelfInterruptTest.bas

```
'SelfInterruptTest.bas  8/9/09
low 4                   'Discharge cap at start
SetInt %00000100,%00000100  'Input 2 going plus
b6=50                   '500 uSec to start
high 4                  'Start charging cap

MainProgram:            'Just for demonstration purposes
pulsout 1,b6            '500 to 600uSec.
pause 1                 '1 millisecond
goto MainProgram

Interrupt:
low 4                   'Discharge cap
inc b6
If b6<60 then GoOut
b6=50

GoOut:
SetInt %00000100,%00000100  'Input 2 going plus
high 4
Return
```

Self-interrupting PICAXE

I needed to periodically update a variable in a PICAXE18X program and rather than use a PICAXE08 or external multivibrator, this arrangement lets the 18X interrupt itself in a multivibrator-like manner. The circuit can be switched to mode A or B, with switch S1.

Note that mode A has a much narrower frequency range than mode B which switches in emitter-follower Q1.

After initial discharge, the 1µF capacitor starts charging and when its voltage reaches the threshold for IN2, an interrupt occurs and the capacitor is discharged through the 100Ω resistor and diode D1. The interrupt routine then increments the b6 variable after which control is returned to the MainProgram.

The test program (SelfInterruptTest.bas) is shown in the accompanying panel and can also be downloaded from the SILICON CHIP website.

Bill Humphrey,
Kohimarama,
Auckland, NZ ($30)

S1 POSITION	A	B
T1max, milliseconds	11	200
VR1, kilohms	25	1000
V1, volts	0.8	0.5
V2, volts	1.2	1.2
T1min, milliseconds	5	5
VR1, kilohms	11.8	17.8
V1, volts	1.0	0.5
V2, volts	1.7	1.3

Trailer wiring tester

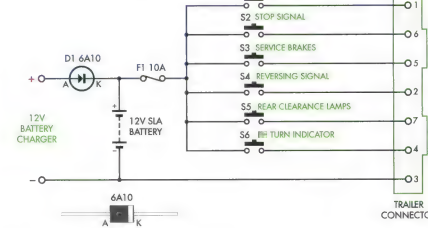
Those who were interested in the Trailer Lights Test Circuit in the December 2009 issue may also be interested in this somewhat simpler approach which only tests the trailer wiring and not the socket on the towing vehicle.

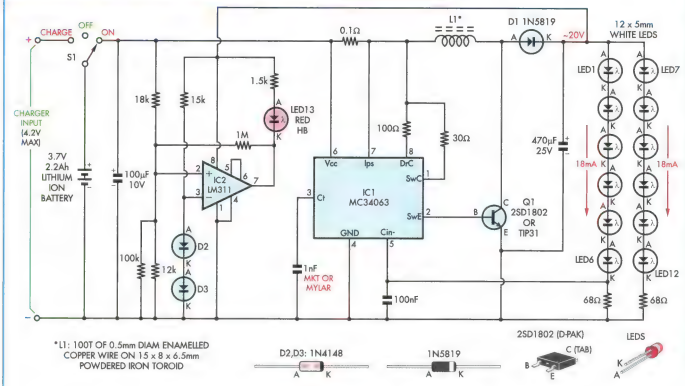
As can be seen, it uses a common feed from a 12V SLA battery and a pushbutton for each lighting circuit to be tested. Testing is straightforward: just press a button and the appropriate trailer lamp should light.

Naturally, the switch ratings should be sufficient to cope with the lamp currents, including the initial switch-on surge.

The charger connection via diode D1 would only be necessary if extended testing of the trailer lights is likely to unduly discharge the SLA battery. SLA batteries can be permanently damaged if discharged below 11V (for a 12V battery).

Peter Boyle,
Edithvale, Vic. ($30)





Lithium-ion powered reading light

This reading light uses an array of 12 white LEDs in two series strings of six. Driving six white LEDs in series requires a voltage in excess of 21V and this is provided by an MC34063 switchmode IC which drives transistor Q1 (the latter is necessary to cope with the total LED current). The suggested transistor is a 2SD1802, a surface-mount device soldered to a piece of copper sheet measuring 10 x 40mm. If this proves difficult to obtain, use a TIP31 instead.

The switching inductor is wound on a powdered-iron core (Jaycar LO-1242) with 100 turns of 0.5mm-diameter enamelled copper wire.

The MC34063 is used in constant current mode and provided the battery voltage is more than 2.5V, it will maintain 1.25V at its pin 5 and across the 68Ω resistor in series with one of the LED strings. This results in a current of 18mA through both LED strings.

IC2, an LM311 comparator, is used as a low-battery monitor. When the battery voltage drops below 3V, the red LED (LED13) is turned on to indicate that charging is required.

Charging can be performed using a DC supply of no more than 4.2V (absolute maximum). This should be monitored via an ammeter. When the current drops to a low value, stop the charge. Charging a 18650 2.2Ah lithium cell takes about two hours.

John Russell,
Bangkok, Thailand. ($50)

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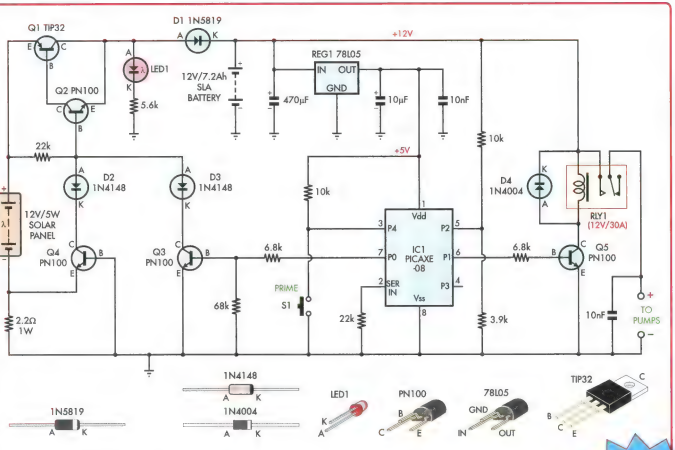

PICAXE-controlled watering system

This project was developed after the loss of several fruit trees during the Melbourne summer of 2008. The idea was to automatically water each tree several times over a 24-hour period using tank water, as economically as possible.

The circuit is powered by a solar panel and sealed lead-acid (SLA) battery. The solar panel charges the battery via a Darlington transistor pair (Q1 & Q2) which is under the control of a PICAXE08M (IC1).

The battery voltage is monitored via the P2 input (pin 5) which has an analog-to-digital converter (ADC). As the battery voltage rises to approximately 14V, P2 reaches its set ADC value and the P0 output (pin 7) goes high to switch on transistor Q3 and thereby switch off the Darlington pair (Q1 & Q2).

The charge current is controlled to protect the solar cell by monitoring the voltage across the 2.2Ω resistor in series with the negative side of the panel. If the charge current rises to about 300mA, the voltage across the 2.2Ω resistor will rise to 0.7V and this will turn on PNP transistor Q4. This pulls down the base of Q1 via diode D2, thereby reducing Q1's base current and limiting the charge current to the chosen value of 300mA.

Prime switch

S1 is the prime switch, to allow the pump to be primed in readiness for use. With my installation, a prime period of 60 seconds works well. An interrupt was used to allow a prime at any time and not interfere with the programmed cycle. Switch S1 pulls the P4 input (pin 3) low and this causes the P1 output (pin 6) to go high, turning on transistor Q5 and the relay.

When the relay is on, the PICAXE-08m does not monitor the battery voltage. To guard against the possibility of the voltage rising too high on a sunny day, the charger involving Q1 & Q2 is switched off via Q3 for the period of the relay cycle.

The relay switches two 12V boat bilge pumps that service two separate water distribution circuits. They are readily available, draw only a couple of amps of current and are capable of pumping 500GPH or 2200l/hr. Both pumps are housed in a 220-litre barrel and the water is distributed via half-inch poly pipe, small couplings and tubes to the plants.

To prevent siphoning, the simplest way is to put a small hole in the poly pipe above the maximum water line inside the barrel. The pumps work so well that there is no obvious loss in pressure or efficiency. The bonus of doing it that way is that you can see that the pumps are working.

Some experimenting is required to adjust the timing to set the number of cycles per day and the length of each watering cycle to suit your particular garden. In my installation, I adjusted the watering cycle and period to deliver between 1.2-1.5 litres per plant per day. This program provides water to 20 plants.

Paul Walsh,
Montmorency, Vic.

Note: the software for the PICAXE (plantwater.bas) can be downloaded from the SILICON CHIP website.

SERVICEMAN'S LOG

Modem rage – it's not a pretty sight

Modem rage, like road rage, is an ugly sight. So how does a normally urbane, cheerful, mild-mannered individual completely lose it over such a simple piece of technology? All too easily, as it turns out.

Items Covered This Month

- Modem rage
- How reliable are ECUs in cars?
- An embarrassing antenna installation
- Birds of a feather
- Not the best design

I have a friend who I've known for over 30 years now. He is kind to his dog, loves his wife and kids, is considerate to his neighbours and is not at all the type to get involved in road rage.

But modem rage . . . well that's an entirely different matter.

It all started some six months ago when he decided to subscribe to an ADSL2+ service via a well-known ISP. The transaction went smoothly and the modem was delivered to his home the very next day. All he had to do to achieve internet nirvana was plug it in and go through the step-by-step setting-up procedure.

Well, he did that but it stubbornly refused to work, despite his repeated and increasingly vocal attempts to coax it to do so. Eventually, after a couple of hours of futile effort, he was forced to admit defeat and seek help from the ISP's tech-support line.

The tech-support guy was very helpful and patiently went through the modem's settings with him. He got him to change a couple of the settings and then, all of a sudden, it started working. Hallelujah! Oh joy unrestrained.

Unfortunately, my friend's joy was to be short-lived because it stopped working again a short time later. Feeling somewhat exasperated at this, he spent another hour or so on it and then rang me to see if I could help. We went through his modem settings once more but as far as I was concerned, everything was correct.

I then asked him whether the ADSL LED on the front of the modem was lit. After all, there's no way it would work if it wasn't acquiring the ADSL line correctly. His response to this was a bit vague but I got the impression that sometimes the ADSL LED was on while at other times it was flashing.

I wasn't familiar with his particular modem but the flashing ADSL LED didn't sound right to me, so I advised him to try changing the telephone cable. If the cable he was using had an intermittent connection, then that would account for his problems.

I left him to it while he did the swap and he rang back a few minutes later to say that my diagnosis was spot on. Swapping the cable had indeed fixed the problem but then, to his considerable frustration, it stopped working again while we were talking.

His next step was to call his ISP again, to see if they could offer further advice. They eventually transferred him to the modem's manufacturer in the US and a very helpful technician again went through all the modem's settings with him once more. They changed a couple of minor settings and lo and behold, it suddenly started working again.

Well, it worked until just after the phone call ended. It then packed it in yet again and my friend, by now feeling thoroughly hot under the collar (well, frothing at the mouth, actually), rang his ISP. It wasn't a pleasant conversation. As far as he was concerned, the modem was faulty and he wanted a replacement yesterday and he told them so in no uncertain terms.

They promised a new one as soon as it could be organised.

At that stage, the weekend intervened but my friend was desperate to get his Internet connection working. His daughter urgently needed access to download some university work and he was being harassed by both her and his wife to come up with a solution.

And so the harassed one sought my assistance once more. Could I drop by on Saturday afternoon and take a look at that !@#$% modem please?

Well, I dropped by and the first thing we did was quickly go through his settings once more. These were all OK and I then noticed that the ADSL LED on the modem was flashing, as though it was trying to acquire the line. I reached around the back of the modem and wriggled the telephone cable and it briefly came good, so it seemed like an intermittent contact problem.

But something wasn't quite right – the plug seemed loose so I gave it a push and there was an audible click as it slid all the way into the socket. The ADSL LED then quickly came on as the modem acquired the line and we had full Internet access.

And that's all it was – my friend simply hadn't pushed the telephone cable plug all the way home into the modem's socket until the retaining clip clicked into place. Instead, it was almost there, the matching connectors occasionally making good enough contact for it to work for brief periods.

Just think – all that frustration, all that modem rage, all those wasted phone calls, all that wasted time and all those intemperate, naughty words in front of his wife over such a simple thing.

I must say that he took it all rather well and in very good humour, if a little sheepishly. Apparently, his wife

~ APPARENTLY, HIS WIFE STILL MENTIONS IT WHEN SHE WANTS TO MAKE A PARTICULAR POINT

still mentions it occasionally when she wants to make a particular point.

My next story again comes from my mate in the car repair business. He's got some interesting facts on ECU failures in cars and I'll let him tell it in his own words . . .

ECU failures

In our business, we see lots of ECU failures in modern cars (ECU = Electronic Control Unit or Engine Control Unit). Of course, these failures are very small in overall percentage terms because statistically, modern cars are much more reliable than cars of decades past. However, because of the sheer number of cars on the road, the number of faulty ECUs we encounter is quite high, especially for a smallish 4-man suburban automotive workshop.

The question I often ask is what is the most common cause of these failures. Are the ECUs of poor quality? With a few exceptions, the answer is a resounding "no". Are many failures due to human intervention? Again with a few exceptions, no. Are the systems, as a whole, of poor design? In my opinion, the answer to this, in some cases, is "yes!".

To explain, we often hear of automotive ECUs being "spiked" or destroyed due to a voltage spike caused by jump-starting or the like. However, I seldom believe this. I'm going out on a limb here but after nearly four decades in the auto industry, I've only seen a small number of ECUs that have been damaged in this fashion.

By "small number" I mean less than the number of fingers one has on both hands. And even then, in nearly all those cases, the probable cause was that of reverse polarity, not a voltage spike as such. The number of spike-damaged ECUs is so small as to almost put them into the category of an urban myth.

What about the general build quality of the ECUs themselves? I'm going out on another limb here but nowadays, virtually all manufacturers' ECUs are of the same excellent quality internally. This includes anything from a $13,000 drive-away Kia to a top-shelf $450,000 Mercedes Benz (puts on flak jacket and runs away).

However, in years gone by, certain manufacturers produced ECUs that were not as good as they could have been. Many units suffered from poor soldering, leading to chronic dry joint faults, while several others utilised components that were "below par". The most common offenders in this area were sub-standard or inadequately-rated electrolytic capacitors which, after just a few years from new, proceeded to leak their innards all over the PC board.

By and large, most automotive ECU failures are caused by the failure of another component in the EFI system, eg, short circuits in ignition coils, idle control motors and wiring harnesses. Some European cars are fitted with "environmentally-friendly" "biodegradable" wiring insulation. Unfortunately though, it prematurely degrades while in use, causing much grief many years later when some of the now-bare copper conductors come into contact with each other.

In such cases, the cost of repairing the ECU pales into insignificance when compared to the cost of replacing the entire engine wiring harness (using genuine parts). Add in the replacement of any faulty ignition devices along the way and the cost of many hours labour and it can be quite an expensive exercise.

One recent Japanese model has an annoying habit of allowing the engine coolant to leak into the idle control stepper motor when things go wrong. Combining a boiling water/glycol mix with fine insulated copper-wire windings never leads to a happy ending. Either the idle motor itself or the transistor drivers inside the ECU can fail or, more commonly, both can fail. Again none of this is inexpensive to owners accustomed to a $200-300 fee for a standard car service.

A common belief among the motoring public is that certain Japanese cars are "far" more reliable than other cars. This stems from the fact that Japanese products developed from being seen as cheap and nasty in the 1960s to being virtually world leaders in quality by the 1990s. Since then, economic realities have intervened and many Japanese automakers now source their ECUs from factories in countries other than Japan. Most are of good quality but a few are not so good.

So that's the story on ECU failures – they're mostly caused by the failure of other parts in the system.

The next story comes from G. K. of

Serviceman's Log – *continued*

THE DUTCH GENTLEMAN WAS THOROUGHLY TAKEN ABACK...

Birkdale in Qld. You never know what you might find when you go fishing for cables in wall cavities. Here's how he tells it . . .

How embarrassing

This story is rather embarrassing but true.

I was called out to install an antenna system in a house by the new owners. A quick glance at the chimney on arrival revealed an old 300-ohm ribbon cable dangling from under the tiles, so this could most likely be used to pull the new coax I needed to install up the wall. It was a good start, or so I thought!

I knocked on the door and introduced myself and the owner, an elderly Dutch man, led me into the lounge room to the TV. Yippee! – there was a 30mm hole on the skirting board at the bottom of the internal feature brick wall where a socket had been. This was going to be a piece of cake!

I whipped out my trusty coat hanger with "calibrated" hook and inserted it in the hole to see if I could snare the ribbon cable but no luck. I eventually gave up on this approach and decided to try my luck at the other end. As a result, I retrieved my step ladder from the van and got up into the ceiling. My plan was to drop my string line and sinker down the wall cavity to the hole below.

The ribbon cable entered the wall cavity in the expected position, so it was puzzling that I was unable to hook it from below. Anyway, I dropped my string line down the cavity, then repeated my search with the coat hanger at floor level again.

This time, I was searching for the string line but there was nothing, much to my growing frustration. I pushed the coat hanger in further, twisting it about as I did so and this time when I pulled it out I had some plastic attached to the hook!

Was it from the damp course? I didn't know so having removed it I pushed the hook back in again only to find . . . you guessed it . . . more plastic. I then repeated this procedure for some 15 minutes, the pile of plastic growing all the time.

Not wanting to give up, I then bent the coat hanger and went in at a slightly different angle. And lo and behold, this time I was sure I had hooked something different because it was difficult to withdraw. Could it be the ribbon and string line twisted together? I persevered and it was something different alright because I eventually dragged a dainty pair of women's knickers through the hole!

The Dutch gentleman, who had been keenly observing the whole process, was thoroughly taken aback at the arrival of a pair of knickers through the wall of his house. He called to his wife: "Look at dis Lurf. De Teefee man has found a pair orf women's knickers in der wall".

"Dey are mine", she explained.

"Come orf it . . . how duz a pair orf your knickers get into der wall?"

"Dey weren't in der wall Effie. Dey were in der bedroom wardrobe!"

Oh yes, you have days like this! A quick check in the bedroom on the other side of the wall revealed the wardrobe, along with the original 300-ohm ribbon cable stapled to the framework and my string line down the rear corner. And at floor level, there they were – mutilated plastic supermarket bags of the lady's knickers!

As Effie would say " How embarrassment!".

In hindsight, the fact that it was a feature brick wall should have been my clue. It is single brick and leads straight into the wardrobe, with access to the ceiling and then to the chimney mount and antenna.

Oh well, we live and learn. I was a bit stressed at the time but can look back on it now and laugh. Thank good-

Servicing Stories Wanted

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and be sure to include your full name and address details.

ness I was self-employed at the time and didn't have a boss to kick my backside for all the wasted time I couldn't charge for.

OK, so what happens when birds of a feather flock together? This next story from R. R., West Heidelberg, Victoria, has the answer . . .

Birds of a feather

As part of the Australian airways guidance system, there has been for over 50 years a "non-directional beacon" (NDB) – or homing beacon (homer) – at Wonthaggi, about 100km south of Melbourne.

Back in the 1950s, when it was first installed, it used to routinely exhibit a mysterious "fault". This fault caused it to automatically switch to duplicate standby equipment and signal the change by adding a "pip" to the Morse identification, which was routinely monitored by the "Aeradio" operators at Melbourne airport.

On each occasion, an Aeradio technician would be dispatched to Wonthaggi, only to find that everything was working faultlessly on both the main and standby equipment. And with everything seemingly working correctly, there was nothing they could do to locate the fault and fix the problem.

The fault proved to occur nearly always just after sunrise and after a few weeks it became clear that the only way to find it was for a technician to stay overnight in Wonthaggi. He could then get out to the NDB just before sunrise, hook up an RF output meter and watch what happened.

The result was rather unexpected. As dawn approached, he suddenly heard lots of "squawking" outside and this was accompanied by an equally sudden large fall in the RF output reading on the meter. He immediately rushed outside and observed hundreds of starlings sitting on the antenna.

NDBS work in the LF band (200-400kHz) and require a vertical radiator. In this case, the vertical radiator was 21 metres long and was tuned using three horizontal wires, each about one metre apart and 70 metres long and connected to the top. Thus any change in the capacitance of the top (in this case due to the birds) had a very sensitive effect on the tuning, leading to a large loss in RF output from the transmitter.

After their early get together, the birds quickly dispersed for the day and the system came good.

Scarecrows, noise scaring techniques, wire greasing and various other methods were all either tried or rejected as impractical and the solution had to wait until the availability of a robust automatic tuning system quite some time later.

Finally, this last story is from N. V., Sydney, NSW.

Not the best design

I recently bought a UHF remote-controlled power point for my parents after using the same model myself for over a year. Their new desk lamp (a converted heat lamp) certainly is stylish but the lack of a power switch on it is an inconvenience. A $20 remote-controlled power point seemed like an elegant solution.

So I installed the small 12V battery in the transmitter unit and then plugged the switch unit into mains. All appeared to work well – pressing the buttons on

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the remote turned the lamp on and off as expected. However, I noticed a few minutes later that the red transmit light on the remote control was flickering even when no buttons were pressed.

It hadn't done that immediately, though. The LED was off immediately after I had installed the battery but it then slowly became brighter over time. Eventually, the lamp switched itself on even though nobody had touched the remote. I checked that none of the buttons were stuck down but they seemed fine.

It was clearly time to open it up. Luckily, after removing two screws, the plastic case unsnaps easily. Inside I found eight tactile buttons, a switch, a veritable forest of 1N4148 small signal diodes, an LX2262A-R4 UHF encoder IC, a PNP transistor, a handful of resistors and ceramic capacitors, the red LED and a metal can type device. The latter apparently contains some kind of tuning coil, as it's attached to the IC's RF output pin.

It's hard to find data on the LX2262A-R4 but I had a hunch that the PT2262 is a compatible chip and the pin-outs corresponded with the unit on the PC board. Interestingly, the sample schematics in the PT2262 data sheet show fewer diodes to achieve roughly the same functionality and I wondered why the designers of this device came up with a more complex configuration.

Tracing the circuit revealed the device's operation. The PNP transistor acts as a power switch. There is a base/emitter resistor which keeps it off normally and another resistor from the base to the button network. When you press a button, the button sinks current from the base via a network of 1N4148s, turning it on and thus powering the IC.

In addition, each button is connected via another network of diodes to the data and address pins of the IC, which have pull-up resistors attached. So the default state of each input is high when power is applied but if you press a button, the corresponding input is pulled low. Thus the buttons control both the power supply and the voltages on the data and address lines.

Measuring the base-emitter and collector-emitter voltages of the PNP transistor showed that it was switched on constantly. So that was the reason for the flickering LED and the spurious transmissions.

I suspected that one of the buttons had dirty contacts, causing it to conduct enough current to turn the transistor on. As a result, I started desoldering the 1N4148s in an attempt to discover which one was at fault. Eventually, I found that removing certain diodes "fixed" the problem and by using a process of elimination, I was able to eventually trace the current sink to pin 2 of the transmitter IC. This is the A1 address input.

So it was the IC itself that was sinking the current and having discovered that, the problem became obvious.

Pressing certain buttons pulls pin 2 low, clearing bit 1 in the address being broadcast. But because of the dual purpose of those buttons, when you are not pressing any of them, current can flow from the base of the PNP transistor through to this input pin on the IC. Normally, this sort of event is prevented by the 1N4148 diode network but unlike the other address lines, pin 2 just happens to have a direct path back to the transistor's base.

So 12V is being applied to this input when the IC has no supply rail V_{CC}. The data sheet is rather thin on details but normally the acceptable voltage on any input pin is roughly between ground and V_{CC}. If you apply voltages outside this range, unless the IC is specifically designed to handle it, strange things can happen.

Presumably the IC inputs don't have clamping diodes or else this circuit would never have worked. I suspect that due to sample-to-sample variation, some ICs will tolerate this voltage with no ill effect but others will suffer from input transistor degradation and they will start sinking current. This explains why the remote was fine at first but became problematic after a few minutes.

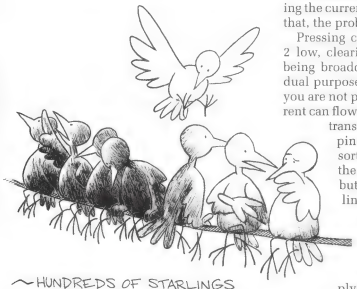
The flickering evidently occurs because once the transistor turns on, V_{CC} rises to normal levels and presumably the leakage current into that pin drops off, allowing the transistor to switch back off again. This essentially forms an oscillator.

The solution was simple. I did what the manufacturer should have done in the first place and replaced the wire link joining pin 2 of the IC to the button/diode network with another 1N4148 diode. This means that when you press a button it's still able to sink the pull-up current and set the input correctly but no current can flow the other way, into the IC's input from the transistor.

And that fixed it. After reassembling the device and reinstalling the battery, it worked fine and the LED ceased flickering. I get the feeling somebody decided to save a fraction of a cent per unit by replacing a diode with a wire link. It probably worked on a prototype so they figured it was a harmless change. Well, the replacement component wasn't very expensive but I can't say the same about the time it took me to figure it out.

And those sample schematics I mentioned from the PT2262 data sheet? They suggest you skip the transistor altogether and just use the buttons to form a path between the battery and the IC's power supply. A voltage divider connected to each button is used to drive the inputs and there is one diode per button to isolate these two functions.

Such a scheme avoids the problem I encountered since the input pins are pulled to ground by default. Arguably, by adding the transistor, you can extend the battery life slightly but I don't think the additional complexity is worth it. SC



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NEW

VOLTAGE MODIFIER KIT

Refer: Silicon Chip Magazine December 2009

This kit intercepts and alters the signal from engine sensors that supply a voltage signal to the engine control unit (ECU). Restore correct air/fuel ratios after engine modifications, prevent engine boost cuts, or alter sensor signals for improved drivability. Requires a hand controller for programming, RS232 cable and a suitable input signal. Kit includes PCB, case and electronic components.

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2 Way Kevlar Coaxial Speakers (sold as a pair)

5"	Cat. CS-2372	Was $99	**NOW $49 Save $50**
6.5"	Cat. CS-2374	Was $119	**NOW $59 Save $60**
6 x 9"	Cat. CS-2378	Was $149	**NOW $69 Save $80**

Kevlar Split Speakers

6"	50WRMS Cat. CS-2327	Was $159	**NOW $69 Save $90**
6.5"	60WRMS Cat. CS-2329	Was $169	**NOW $79 Save $90**

Subwoofers

10"	Cat. CS-2352	Was $219	**NOW $109 Save $110**
12"	Cat. CS-2354	Was $249	**NOW $119 Save $130**

6.5" 60WRMS Kevlar Component Car Speakers
Cat. CS-2338 Was $299 **NOW $149 Save $150**

Car Ribbon Tweeter with Crossover
Cat. CS-2339 Was $89.95 **NOW $44.95 Save $45**

2 MEGAPIXEL MINI DIGITAL SPY RECORDER

The ultimate in discrete portable photo & video recording from business meetings to outdoor sports activities. A 2GB Micro SD can support up to 8GB of memory. Includes case, lanyard, two mounting brackets, software, USB & mains plugpack.

- 2 megapixel camera
- High speed recording and fast response
- Low light recording
- 30fps for 640 x 480 video output
- Manual and sound activated recording functions
- Supports AVI & JPEG formats
- Rechargeable Li battery lasts for 2 hours of non-stop recording
- Measures 55(H) x 20(W) x 28(D)mm

$199.00
Cat. QC-8001

NEW

NEW

HANDHELD USB 60X MICROSCOPE

A colour zoom CMOS video camera that is mounted in a microscope style housing. The system connects to your computer via the USB port and microscope images are viewed on your computer screen as either a snapshot or a video stream. Both can be saved for later viewing. The system has its own LED illuminators so there is always plenty of light for viewing. Accessories include specimen slides, eye dropper & tweezers.

- Up to 640 x 480 image resolution
- Maximum magnification 60X
- Size: 100(L) x 38(Dia)mm

$59.95
Cat. QC-3248

All catalogue items are limited to reasonable retail trade quantities. Stock limited, all cards subject to availability.

Free Call: 1800 022 888 for orders!

Jaycar electronics
Better, More Technical

Back To Work...

portasol® Pro Piezo Gas Soldering Tool Kit

This Kit contains a Portasol Pro Piezo Gas Soldering Iron, and all of the following parts.

- Quality storage case
- Cleaning sponge and tray
- 2.4mm double flat tip (TS-1312)
- Hot air blow (TS-1314)
- Hot knife tip (TS-1315)
- Hot air deflector
- Flame tip (TS-1316) **Was $129.00**

SAVE $10

$119.00 Cat: TS-1318

portasol® Super Pro Gas Soldering Tool Kit

Features 90 minute run time, 10 second fill, maximum 1300°C temperature and 40 second heat up. The kit contains a Portasol Super Pro Gas Soldering Iron, and all of the following:

- Quality storage case
- Cleaning sponge and tray
- 2.4mm double flat tip (TS-1322)
- 4.5mm double flat tip (TS-1323)
- Hot air blow (TS-1324)
- Hot knife tip (TS-1325)
- Hot air deflector **Was $159.00**

SAVE $20

$139.00 Cat: TS-1328

50W Temperature Controlled Soldering Station

An effective yet simple soldering station that features a ceramic heating element to provide precise temperature control. The soldering iron weighs just 45g which makes it ideal for comfortable long term use.

- Temp. Range 200 - 480°C
- Power consumption 60W
- Operating voltage 240VAC
- Control unit 140mm long

Was $109.00

SAVE $30

$79.00 Cat: TS-1660

Pocket Wire Stripper

Strips anything from 20 to RG6 coax. Easy to use and small enough to take anywhere on the job.

- 120mm long

NEW

$14.95 Cat: TH-1817

ESD Safe Sidecutters

Specifically for ESD work. High quality Japanese designed, Italian manufactured cutters especially for static-sensitive applications. 135mm long.

NEW

$29.95 Cat: TH-1922

Mini Non-Contact IR IP67 Thermometer

Ultra compact, non-contact thermometer. IP67 rated so is ideal for industrial and lab applications. LCD readout gives temperature in Celsius or Fahrenheit. Batteries and lanyard included.

- Measurement range: -33 - 110°C (-27 - 230°F)
- Accuracy: ±2.5°C
- Response time: 1 second
- Size: 82(L) x 17(Dia)

$39.95 Cat: QM-7218

1000V - 7 Piece Screwdriver Set

High quality, bright red drivers you can find easily. Insulated right to the tip and rated to 1000V

- Drive sizes: Flat: 1.2x6.5x150mm, 1x5.5x125mm, 0.8x4x100mm, 0.6x3.5x75mm
- Phillips: #2 x 100mm, #1 x 80mm, #0 x 60mm.
- Includes storage box.

$24.95 Cat: TD-2022

Non-Contact Voltage Tester

Combining two instruments: a non-contact AC voltage detector and IR thermometer. It provides easy and safe testing of mains voltages and heating systems. Essential tool for tradesmen.

- Detects AC voltage up to 1000V with LED indicator
- Precise non-contact temperature measurement
- Automatic range selection Resolution 0.1°C (0.1°F)
- Celsius or Fahrenheit
- Automatic power-off
- Dimensions: 155(L) x 24(Dia)mm **Was $59.95**

SAVE $20

$39.95 Cat: QP-2269

Temperature/Humidity Datalogger

A must for anyone involved with food preparation, archiving or storage. These USB dataloggers log temperature and humidity readings and store them in internal memory for later download to a PC.

Features:

- 32,700 memory values
- Adjustable measurement cycle
- Analysis software included
- Alert if user-defined max/min values are exceeded
- Celsius and Fahrenheit

$179.00 Cat: QP-6014

Pro Sound Level Meter with Calibrator

Suitable where accuracy, repeatability and validation is required. Ideal for vehicle noise testing, race scrutineering, traffic noise, aircraft noise or any evidence-based noise testing. Conforms to IEC 61672-1 Class 2 for sound level meters.

Features:

- Backlit LCD
- Analogue outputs
- Min/Max measurement
- A & C weighting
- Calibrator included

Specifications:

Accuracy: ±1.4dB
Frequency range: 31.5Hz - 8kHz
Dimensions: 278(L) x 76(W) x 50(D)mm

$399.00 Cat: QM-1597

High Quality Banana Piggyback Test Leads

A set of factory-moulded piggy-back style banana plugs, each connected by one metre of high-quality 500VDC 12A rated cable. The set contains 2 x black, 2 x red and 1 each of blue, yellow and green leads - 7 in all.

NEW

$24.95 Cat: WT-5305

Protek 608 True RMS DMM with PC Interface

Suitable for lab, development and serious testing applications, this powerful meter has enough features to make it a legitimate replacement for a bench multimeter. The 50,000 count display gives four decimal place accuracy and the internal memory can store and retrieve up to 10 readings. If you need more storage than that, the RS-232 cable allows you to store and log measurements on a PC with the packaged software. If you're looking for a DMM with data storage and logging capability, this meter offers value for money.

- Display: 50,000 count
- Category: Cat III 600V
- Basic DCV accuracy: 0.050%
- Carrying case and holster included
- RS-232 cable and software included
- Windows NT and XP compatible
- Ave/RMS: True RMS
- Dimensions (with holster): 216(H) x 104(W) x 58(D)mm **Was $349.00**

SAVE $50

$299.00 Cat: QM-1292

Autoranging SMT DMM

Specifically designed for SMT work with interchangeable probes and tweezer probes

$79.95 Cat: QM-1496

NEW

- Continuity test
- Auto power-off
- SMT probes
- Display: 6000 count
- Security class: CAT III 600V
- Basic DC accuracy: 1.5%
- Dimensions: 110(H) x 36(W) x 21(D)mm

Autoranging DMM

An accurate and easy-to-use autoranging DMM. Just select the parameter you want to measure and the meter chooses the appropriate display range which you can override manually if you want to. It also does capacitance, frequency and diode test.

- Display: 4000 count
- Category: Cat II 600V
- Autoranging
- Data hold
- Relative measurement function
- Auto power-off
- Holster included
- 10A AC & DC
- Dimensions: 150(H) x 75(W) x 33(D)mm

$34.95 Cat: QM-1535

All savings are based on original recommended retail prices.

Back To Work...

Trade Quality Digital Multimeter

This pocket-sized DMM has an excellent range of features including an easy one finger dial selector on the front.

- Display: 5000 count
- Cat II 600V / Cat III 300V
- Basic DCV accuracy: 0.500%
- Dimensions: 112(H) x 56(W) x 12(D)mm

Limited stock

Was $59.95

$39.95 Cat: QM-1544

SAVE $20

Trade Quality Digital Multimeter

Ergonomically designed slim shape with one hand operating knob and buttons. An excellent investment for the apprentice to the professional tradesman.

- Display: 4000 count
- Cat IV 600V
- Dimensions: 164(L) x 82(W) x 44(D)mm

Limited stock

Was $199.00

$139.00 Cat: QM-1625

SAVE $60

Industrial Storage Cases

Built for the rough and tumble of the building site, factory or workshop. Made from sturdy ABS with solid clasps and removable compartment trays so you can take parts with you to the job. Two sizes available:

15 Compartment (Cat. HB-6304)
- 12 compartments: 55(L) x 40(W) x 50(D)mm
- 3 compartments: 80(L) x 50(W) x 50(D)mm
- Case size: 335(L) x 205(W) x 60(D)mm

$8.95 Cat: HB-6304

$14.95 Cat:HB-6305

19 Compartment (Cat. HB-6305)
- 4 compartments: 55(L) x 40(W) x 50(D)mm
- 8 compartments: 80(L) x 50(W) x 50(D)mm
- 7 compartments: 110(L) x 80(W) x 50(D)mm
- Case size: 335(L) x 205(W) x 60(D)mm

1 12/24V Switchmode 7A Battery Charger

This is a 5 stage full maintenance charger for 12 and 24V lead acid (SLA, wet, gel and AGM) batteries with bonus features.

Fully automatic charging modes with diagnostic and recovery features, it even features a power supply mode where it can act as a 13.6VDC 5A power supply. A versatile charger with six different microprocessor-controlled modes of operation. See website for details.

- Input: 170 - 260VAC
- Input current: 400mA max
- Charging current: 12V-7A, 28V-3.5
- Dimensions: 140(L) x 60(W) x 35(H)mm

$149.00 Cat: MB-3606

Heatshrink Assortment Trade Pack

All the heatshrink the technician, tradesman or serious hobby user will ever need. The pack contains 160 lengths of different sizes from 1.5 to 10mm in black, red and clear in a handy storage case.

- Case size: 205(L) x 110(W) x 35(H)mm

Was $24.95

SAVE $10

$14.95 Cat: WH-5524

16-Way 100A Brass Distribution Bar

An ideal way to distribute high current paths. An 8mm stud provides for incoming cable and distribution is via 16 screw terminals with 7mm cable entry holes. Solid brass with high quality plastic bridge mounts. Rated for 100A.

- Dimensions: 112(L) x 18(W) x 12(H)mm

Limited Stock

$9.95 Cat: SZ-2004

27D° Rotation Clamp Vice

The base will clamp to any bench or table up to 55mm thick and the 40mm jaws will take a job up to 56mm in size. Once in position, the head is easily fixed in position with a quick release lever.

- Base: 115(W) x 94(D)mm

$39.95 Cat: TH-1769

18mm Flexible Conduit - 2m

For running cable protection in enclosures and machinery or wiring harnesses in hostile environments. Fully flexible, so handles tight radius 90° bends easily. Made from polyethylene, length 2m.

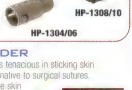
- Outside diameter: 18mm
- Inside diameter: 14mm

$4.50 Cat: HP-1320

Flexible Conduit Adaptors

Made from polythylene

3/4" - 2 pc	Cat. HP-1300 $3.95
3/4" - 10 pc	Cat. HP-1302 $14.95
3/4" - Panel Mount 2 Pk	Cat. HP-1304 $3.95
3/4" - Panel Mount 10 Pk	Cat. HP-1306 $14.95
3/4" - Removable 2 Pk	Cat. HP-1308 $7.95
3/4" - Removable 10 Pk	Cat. HP-1310 $29.95



HP-1300/02

HP-1308/10

HP-1304/06

20 Piece Micro Drill Set 0.3 - 1.6mm

20 micro drills in indexing storage case for easy removal. Ideal for drilling wood, composites, plastic or soft metals.

- Sizes: 0.3 to 1.6mm. See website for full range of sizes.
- Case size: 130(L) x 70(H) x 8(D)mm

$12.95 Cat: TD-2406

Super Glue Debonder

Cyanoacrylate, better known as super glue is tenacious in sticking skin together, and has been exploited as an alternative to surgical sutures. Debonder will quickly and painlessly separate skin stuck with super glue.

- 20ml bottle with applicator

$3.95 Cat: NA-1501

32 Piece Precision Driver Set

High quality driver set with all those really small bits. Tactile handle with hardened hex shaft that extends from 140 to 210mm. Ideal for jewellery, model making or electronics. Slotted, Phillips, Pozidriv, Torx and hex. Case included.

$19.95 Cat: TD-2108

Conductive Carbon Grease

Lubricates and improves electrical and thermal connections between sliding surfaces, while providing protection from moisture & corrosion. Excellent for use on switches and EMI shielding applications. Industrial, trade and hobby use. 50 gram tube.

- Prevents contact corrosion
- Reduces make-break arcing and pitting of switch contact surfaces
- Improves the connection between irregular or pitted contact surfaces
- Reduces EMI noise by maintaining a continuous path between conductive surfaces

Due Mid February

$9.95 Cat: NA-1034

Stainless 1W Cree® Tactical LED Torch

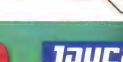
Machined from a solid bar of 304 18/8 stainless steel and O-ring sealed, this is an ideal lighting tool to have in a harsh environment. The 1W CREE® LED gives about 120 hours of burn time and 80 lumens of illumination. With a tactical tailcap switch, it's suitable for security, law enforcement, marine and military use.

- Requires 3 x AAA batteries
- Dimensions: 130(L) x 31(Dia)mm

Was $59.00

SAVE $20

$39.00 Cat: ST-3398



All savings are based on original recommended retail prices.

BACK TO SCHOOL...

ANIMAL ANATOMY MODELS

Fantastic educational tools for teaching how the internal structure of various animals and plants are different to our own. Each model comes complete with a full-colour instruction booklet with information about the organism the model represents. They also have a display stand so you can preserve them for future study.

Ideal for schools or the junior biologist

3D Frog Anatomy Model

With your model frog you can find out all about the internal workings without ever picking up a scalpel. You can remove all the internal organs and limbs and he has detailed finish and colouring. Display stand included.

- 31 parts, approx 120mm long
- Recommended for ages 8+ Limited Stock

$34.95 Cat: GS-2396

White Shark Anatomy Model

Make your own miniature version of Jaws and see why carcharodon carcharias is the perfect killing machine and has survived for 350 million years

- 20 pieces
- Finished model: 335(L) x 200(H)mm

Limited Stock

$34.95 Cat: GS-2392

Tyrannosaurus Rex Anatomy Model

T-Rex was about 15 metres long and lived around 65 - 85 million years ago during the Late Cretaceous period. Build him piece by piece and find out how he managed to digest 230kg of meat per bite.

- 99 pieces
- Finished model: 570(L) x 23(H)mm

Limited Stock

$89.95 Cat: GS-2394

Animal Cell Anatomy Model

All life comes from cells - the simplest building blocks of living organisms and one human being has over 100 trillion of them. You won't have time to build that many, but you can build one to see all the parts that make it tick.

- 24 pieces
- Finished model: 115(W) x 160(H) x 60(D)mm

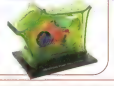
$29.95 Cat: GS-2396

Plant Cell Anatomy Model

See how the smallest parts of plants work.

- 26 pieces
- Finished model: 110(W) x 125(H) x 70(D)mm

$29.95 Cat: GS-2398



HUMAN ANATOMY MODELS

A fantastic educational way to learn about human anatomy and what makes our bodies tick. Each puzzle teaches a different aspect of human biology in great detail. Learn all about vascular, nervous, skeletal, sensor and reproductive systems in a fun and practical way. Each puzzle is highly detailed and have a presentation stand for keeping on display in the classroom or science lab.

3D Human Torso Anatomy Model

This highly detailed model shows all the main organs and they can be displayed in cutaway or complete. You can remove any of the organs and look inside them to see what goes where and why. The complete model is 2.5:1 scale and is 380mm tall.

- 54 parts with full colour instruction manual
- Recommended for ages 8+ ***Was $149.00***

$129.00 Cat: GS-2389

Human Skeleton Anatomy Model

See exactly how the leg bone is connected to the hip bone. All the bones have articulated joints just like real ones and are colour coded to show where the muscles originate

- 34 parts
- 200mm high

Limited Stock

$24.95 Cat: GS-2385

Human Brain Anatomy Model

Highly-detailed brain model to medical education level. Super detailed showing the main parts of the brain and how it connects to the central nervous system

- 32 parts
- 100mm high

$24.95 Cat: GS-2383

Human Muscle & Skeleton Anatomy Model

The perfect model for muscle structure study. It shows how the muscles fit on the skeleton and has transparent parts to show the bones.

- 46 parts, 190mm high

$24.95 Cat: GS-2384

Human Heart Anatomy Model

Find out how the heart and the vascular system works. Assemble the heart and pull it apart again to see how the chambers and valves in the heart keep blood pumping around the body.

- 31 parts
- 95mm high.

$24.95 Cat: GS-2391

For our full range of Human Anatomy Models see in store or website.

MINI SCIENCE KITS

Mini science projects with a difference. Make crystals, superballs, disgusting slime or be your own detective. All the kits have everything you need and include full instructions. Just add a couple of common household items and away you go. Safe, fun and easy. You can buy each project individually, or buy all together in the Super Science Lab. Suitable for ages 8+.

Liquid Crystals Kit

Make dazzling liquid gems, crystals and diamonds. Learn about the science behind them. Discover how your unique creation is used every day to preserve water. Surprise all your friends creating fake ice or an invisible gem

$9.95 Cat: KJ-8930

NEW

Super Ball Mould Kit

Mix and mould two different size superballs and mix the colours up too. Learn what makes the process possible. Experiment with cool science like density and gravity. Enough ingredients to make heaps of superballs.

$9.95 Cat: KJ-8933

NEW

Crystal Forest Kit

Grow your own crystal formation or your own crystal forest. Learn all the facts about what makes crystal formations grow. All of the ingredients you need are provided.

$9.95 Cat: KJ-8931

NEW

CSI Detective Mini Science Project

Learn how to lift fingerprints, even if they're hours or days old. Find out what the important characteristics used in analysing fingerprints are. The kit has enough material for multiple experiments

$9.95 Cat: KJ-8934

NEW

Slime Shop Kit

Gross everyone out with your own snotty slime. Follow the instructions to make your own disgusting slime creation, controlling the slimeness to be as disgusting as you like.

$9.95 Cat: KJ-8932

NEW

Mini Science Projects Set

All the projects together. Save $$ on the individual kits.

$29.95 Cat: KJ-8935

NEW

All savings are based on original recommended retail prices.

Back To School...

256MB Digital Voice Recorder

Record up to 26 hours of voice or notes in either dictation or conference mode, manual-of VOX. Play back through the built-in 30mm speaker or use the included software. An LCD screen keeps track of everything and the simple intuitive layout as easy to use.

- Requires 2 x AA batteries
- USB cable and software included.
- Variable speed playback
- Date and time-stamped recordings
- Dimensions: 97(L) x 45(W) x 18(H)mm

Also available:
2GB 800 Hour Digital Voice Recorder
Cat. XC-0382 $129.00

NEW

$69.95
Cat. XC-0350

10x LED Magnifier with Scale

With all metal construction and glass optics, this superb little magnifier provides 10 dioptre magnification with razor-sharp clarity. Inside the viewer is a graduated scale in metric and imperial graduations so you can actually take measurements of an object. Three LEDs provide crystal-clear illumination of the subject. Science, education or engineering applications. Batteries included.

- Requires 2 x AA batteries (included)
- 10x magnification
- Satin chrome finish
- Size: 160(L)mm

NEW

$29.95
Cat. QM-3539

LED Magnifier Lamp

Clearly see what you're working on with this multifunctional laboratory magnifier. Included is an extension pole that transforms it from a desk top unit into a floor standing unit, also included is a detachable desk-mounting clamp. Can be powered with the provided plug pack or 4 x C size batteries which allows this unit to be used where mains is not available.

- 20 high-brightness LEDs
- 4 dioptre magnification
- 127mm diameter lens
- 1200mm floor mode height
- 600mm desk mode height
- Mains plugpack included
- Base measures: 310(L) x 230(W)mm

$99.00
Cat. QM-3542

NEW

20/130W Soldering Iron Starter Kit

All the soldering essentials for the hobbyist. This kit represents excellent value, the best in soldering we've seen, anywhere. The sum of the individual parts amount to more than double the price we are selling this kit for. Kit contains:

SAVE $5

- 240V 20/130W soldering iron with turbo boost switch
- Spare tip
- Basic stand
- 1mm solder in dispenser tube
- Metal solder sucker with spare tip and O-ring

Was $24.95

$19.95
Cat. TS-1651

Computer Tool Kit

All the essentials for doing some minor surgery to your PC. Don't forget your anti-static strap.

NEW

Kit contents:
- Driver bit handle
- Bits: Slotted 3mm, 4mm. PH 0, 1,T10, T15
- Hex adaptors: 4mm, 5mm
- Tweezers, IC extractor. Pearl catch

$19.95
Cat. TD-2150

92 Piece 12V Rotary Tool Set

Drill, saw, sand, polish, carve or grind in your workshop or out on the road. 90+ bits and attachments cover every possible task you'll ever need. The rotary tool is rated for 12V at 12,000 RPM. Ideal for hobby or professional use. See website for full list of attachments.

NEW

- Case size: 240(L) x 200(W) x 70(H)mm

$39.95
Cat. TD-2451

Low Cost DMM

This is a full featured meter with plug-in 4mm probes and transistor tester. It is the ideal first multimeter and will give years of faithful service.

- DC Voltage: 200mV to 1000V
- DC Amps: 200uA to 10A
- AC Volts: 200V to 750V
- Resistance: 200 ohm to 2M ohms
- Size: 125(H) x 68(W) x 23(D) mm

$9.95
Cat. QM-1500

25MHz Dual Trace Digital Storage Oscilloscope

Ideal entry-level DSO for the advanced hobby user or technician and is particularly suited to audio work. Full data storage capabilities and USB interface so you can store traces on a flash drive.

SAVE $50

- Channels: 2
- Input impedance: 1Mohm
- Bandwidth: 25MHz
- Sampling rate: 500MSa/S
- Max input voltage: 400V P-P, Cat II
- Dimensions: 310(W) x 150(H) x 130(D)mm ***Was $699.00***
- Accessories included : 2 x 10:1 probes, EasyScope software, USB cable.

Also available:
100MHz Dual Trace Digital Storage Oscilloscope Cat. QC-1933 $1,499.00

NEW

$649.00
Cat. QC-1932

SD/MMC Card Webserver In a Box Kit

Refer: Silicon Chip Magazine November 2009

Host your own website on a common SD/MMC card with this compact Webserver in a Box (WIB). It connects to the internet via your modem/router and features inbuilt HTTP server, FTP server, SMTP email client, dynamic DNS client, RS232 interface along with four digital outputs and four analogue inputs.

Requires a SD memory card, some SMD soldering and a 6-9VDC power adaptor.
- Kit includes PCB, case and electronic components.

NEW

$89.95
Cat. XC-5489

Laboratory Desk Top Magnifier Lamp

The perfect laboratory tool for coin/stamp collectors, jewellers etc. This desktop magnifier lamp features a 100mm glass lens that will provide you with 3x magnification. The lamp has a solid base and a bright 12W energy-saving fluorescent lamp. The lamp also features a swivel joint enabling you to position the lens to suit your needs.

SAVE $20

- Replacement fluorescent tube Cat. QM-3521 $12.95
- Base 160mm(dia.) ***Was $49.95***
- Limited Stock

$29.95
Cat. QM-3529

Notebook USB Cooling Pad

This notebook cooling pad simply plugs into your notebook's USB port and has an inbuilt 18cm cooling fan to dissipate heat. Having one large fan results in it being quieter than other pads with multiple small fans. Featuring four non-slip pads and an ergonomically tilted surface.

- Dimensions: 300(L) x 290(W) x 35(H)mm

$13.95
Cat. XC-5210

Mini Roll-Up Wireless Keyboard

Life for business travellers and students just got a lot easier. Now you can have a convenient roll-up keyboard to take on the road or to lectures, and it's wireless.

SAVE $20

- Splash resistant keypad
- Standard QWERTY layout
- Washable and hygienic
- Supports Windows
- Size: 370(L) x 123(W) x 5(H)mm ***Was $69.95***

Also available:
White illuminated Roll-Up Keyboard
Cat. XC-5147 $49.95

$49.95
Cat. XC-5145

All savings are based on original recommended retail prices.

Wireless USB Trackball Remote Control for PC

The trackball works as a mouse and you can type numbers or text in the same way you do with a mobile phone. It also has quick launch keys, plus controls for multimedia use - play, pause, record etc. You can also program macros or single commands into any key. No software or drivers are needed - just plug in the USB receiver and off you go. Requires 2 x AA batteries.

- 2.4GHz 10 metre range
- 19mm optical trackball & mouse keys
- USB dongle receiver
- Microsoft Windows XP MCE/ Vista compatible
- MCE hotkeys
- Dimensions: 190(L) x 50(W) x 39(H)mm

$89.00
Cat: XC-4940

Wireless Trackball Keyboard

NEW

Simply plug in the USB receiver to your PC and this stylish and ergonomic wireless keyboard is good to go. So portable you can easily take it with you to and from your home, office or school workstations. Great for cramped workspaces and much easier to use than a laptop touchpad! A complete PC control interface in one neat package.

- 2.4GHz with 8 channels - 10 metre range
- Windows NT, 2000, XP & Vista compatible
- 12 internet/multimedia hot keys
- Requires 4 x AA batteries

$99.00
Cat: XC-4941

Cat 5e Patch Cables

RJ45 to RJ45.

- 350MHz stranded cable.
- ACMA approved

Cat 5e Patch Cable 0.5m Blue	YN-8200 $3.25
Cat 5e Patch Cable 1m Blue	YN-8201 $3.95
Cat 5e Patch Cable 2m Blue	YN-8202 $5.25
Cat 5e Patch Cable 3m Blue	YN-8203 $6.95
Cat 5e Patch Cable 5m Blue	YN-8204 $8.95
Cat 5e Patch Cable 10m Blue	YN-8205 $14.95
Cat 5e Patch Cable 15m Blue	YN-8206 $21.95
Cat 5e Patch Cable 20m Blue	YN-8207 $24.95
Cat 5e Patch Cable 30m Blue	YN-8208 $37.95

USB Lead

USB A to Micro USB B lead.

- 1.8m length

NEW

$9.95
Cat: WC-7724

8 Port Hub Switch

High performance 8 port, 10/100/1000 N-Way switch increases network performance and reduces congestion. The switch also supports auto-negotiation which allows each port to be operated at a different speed while maintaining maximum throughput. Plugpack included.

$99.00
Cat: YN-8987

NEW

- Max cable length: 100 metres
- Transmission speed: 10/100/1000Mbps
- Size: 180(W) x 103(D) x 27(H)mm

10 Port USB Hub

Ten USB ports. That should be enough for anyone. The two position switch turns all ports on, or only ports 7 - 10. This means you can turn off non-essential peripherals while maintaining power to others - LED indicators tell you which group is live. Includes a 5VDC 2A plugpack required for powered operation.

NEW

$59.95
Cat: XC-4946

- USB 2.0
- USB or mains powered
- Key holes for wall mounting
- Windows 2000, XP, Vista and Mac OS 10.0 compatible
- Dimensions: 172(L) x 36(W) x 27(H)mm

90W Universal Laptop Mains Adaptor

This versatile unit has an output voltage LED display and automatically adjusts output voltage according to which connector is fitted. It also has a USB outlet to charge or power one of your USB devices. Compatible with all major brands. Check our website for compatibility with your laptop.

NEW

- Max output: 90W
- Voltage range: 15-24V
- Current range: 2.04-6A
- Dimensions: 154(L) x 58(W) x 37(H)mm

$79.95
Cat: MP-3475

USB NXT Laptop Speakers

Featuring high performance NXT flat panel drivers in a package small enough to fit in your notebook bag. Conveniently powered by USB, these plug-and-play speakers dramatically outperform inbuilt notebook speakers. Providing high quality sound in a portable take-anywhere package. Being USB, they eliminate hard disk noise that all other non-USB speakers suffer from.

NEW

$49.95
Cat: XC-5199

- Dimensions: 220(L) x 70(H) x 45(D)mm

Clip-On Notebook Speakers

With a unique slimline design, these clip-on notebook speakers are ideal for travelling. They're USB powered and connect via standard 3.5mm audio out jacks. Used either clipped onto your laptop screen or freestanding, you'll experience better sound direction and fidelity than your average inbuilt speakers.

NEW

- Win 2000/ME/XP/Vista compatible

Note: Notebook PC not included

$39.95
Cat: XC-5193

USB 3.0 Leads

USB 3.0 is here and offers data rates of up to 4.8Gbps a quantum improvement over USB 2.0. Two leads available:

NEW

USB 3.0 Plug A to Plug A 1.8m
Cat: WC-7770 $15.95
USB 3.0 to Mini USB 1.8m
Cat: WC-7772 $15.95

$15.95
Each

Keyring Micro SD USB Card Reader

NEW

Microscopic would be the best way to describe this card reader all only 19 x 15mm, and that includes the USB plug. Ideal for the travelling shutterbug.

- USB 2.0 Micro SD compliant
- Keyring lanyard included

$9.95
Cat: XC-4759

Bluetooth to RS-232 Converter

Add short range Bluetooth wireless connectivity to RS-232 based devices. It features one 9-pin female RS-232 socket and an 11mm long SMA screw on antenna. A great way to reduce serial cable mess. Perfect for serial printers, scanners, custom built RS-232 products and a host of other devices.

Specifications:

- Antenna: 11(H)mm - SMA plug
- Led Indicator : SYS (Power) , Pairing
- Dimensions: 72(L) x 30(W) x 14(H)mm
- Class 1 (up to 100M range)

NEW

$169.00
Cat: XC-4130

USB to RS-485/422 Converter

Wire up an RS-485/422 device to the 4 socket terminal block to give your hardware USB connectivity. It features surge protection to guard against unpredictable voltage spikes. Suitable for industrial, military, marine, science and custom built applications. One USB A male to male cable is supplied.

NEW

$99.00
Cat: XC-4132

- Dimensions: 55(L) x 42(W) x 24(H)mm
- Includes a 610mm USB A Male to Male cable

Serial to Ethernet Converter

With this converter, computers can connect to serial devices over Ethernet. It's an ideal solution for people who need to monitor or access RS-232 based equipment remotely or to share them over a network. There is one 9-pin male RS-232 plug, an RJ-45 socket and a terminal block to wire up RS-485 or RS-422 connections. The device can be accessed remotely through a simple web interface.

- Supports 10/100M
- Converts RS-232, RS-485 and RS-422
- Dimensions: 88(L) x 68(W) x 27(H)

$169.00
Cat: XC-4134

Better. More Technical

All savings are based on original recommended retail prices.

POWER

SUPERCOMBI POWER MANAGEMENT CONTROL SYSTEMS

RICH ELECTRIC

Introducing the all-new SuperCombi Power Management Systems

In the future all domestic & commercial properties will use this product. What is it? Firstly, it is a very clever battery charger/inverter for an embedded battery bank in your house, etc. It will even recognise lower off-peak tariffs & charge your batteries at, say, 2.00am. In normal peak usage it works as a high power sine wave inverter replacing standard mains. It will also, if configured work as a zero-time changeover UPS. They are designed for high duty-cycle industrial-type use & can be stacked up to 90kW - with two or three phase configurations if needed.

- Intelligent mains grid power and generator power management
- Green Power Smart feature
- Full continuous output rating up to 70°C
- Solar charging capacity up to 600 amps (requires optional MI-3726 $389.00 or MI-3728 $459.00)
- Battery temperature sensor (optional MI-5278 $69.00)
- Wall mountable

12V 1500W	Cat. MI-5250	$3,199.00
24V 1500W	Cat. MI-5251	$3,199.00
12V 3000W	Cat. MI-5252	$4,399.00
24V 3000W	Cat. MI-5253	$4,399.00

Limited Stock*

NEW

COMBIPLUS POWER MANAGEMENT SYSTEMS

The CombiPlus units have the same bullet-proof build quality as the SuperCombis, but have less sophisticated functionality for those who don't need all the bells and whistles. Each unit features a powerful pure sine wave inverter for sensitive electronics and demanding appliances, as well as a four stage battery charger delivering up to 140 amps. With full power output rated as high as 70°C, the CombiPlus units can be connected to solar panels for battery charging, giving you even more flexibility when mains power isn't available. Like the SuperCombis, these can be stacked for increased power or supply three phase if required.

Two models available, see website for detailed specs:

12V 1500W	Cat. MI-5270	$2899.00
24V 3000W	Cat. MI-5273	$3799.00

Also available:

Data Lead 3m	Cat. MI-5250	$35
Data Lead 5m	Cat. MI-5252	$45
Data Lead 10m	Cat. MI-5254	$55

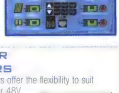
NEW

Multiphase Data Hub for Combi units	Cat. MI-5276	$199
Parallel Stack Data Hub for Combi units	Cat. MI-5277	$199
Battery Temperature Sensor for Combi units	Cat. MI-5278	$69

Limited Stock*

REMOTE CONTROL UNITS

No need to go to the central SuperCombi or CombiPlus unit if you need to make adjustments or monitor performance. The remote control emulates the front panel of the SuperCombi unit exactly, so you can perform all the control or monitoring functions as if you had the unit in front of you. The 1.5 metre lead gives ample scope for positioning the controller at a convenient location in your home or business.



NEW

Remote Control for SuperCombi
Cat. MI-5259 $499.00
Remote Control for CombiPlus
Cat. MI-5279 $379.00 Limited Stock*

LINKABLE 12 - 48V SUNSTAR SOLAR CHARGE CONTROLLERS

These professional grade, high current solar charge controllers offer the flexibility to suit almost any solar installation. System voltage can be 12, 24 or 48V, and multiple units can be stacked together (up to 10 units max) allowing your system to grow and expand without rendering your old charge controller useless. Each unit features an LCD and front panel controls, and can be used as either a battery charger, load controller, or diversion regulator. They can also be connected to a remote control for remote monitoring, and are fully protected against reverse polarity, short circuit, high temperature and overvoltage. Particularly suited to the SuperCombi and CombiPlus units, as they communicate via data cables to exchange charging information. 45 or 60A models available:

NEW

45 Amp	Cat. MP-3726	$389.00
60 Amp	Cat. MP-3728	$459.00
Remote	Cat. MP-3729	$149.00

SWITCHMODE MULTIVOLTAGE PLUGPACKS

These switchmode plugpack adaptors are slim in size, lightweight, and feature manually selectable variable voltage outputs. All are MEPS compliant and come supplied with 7 plugs and a USB output socket. (MP-3318 does not include USB socket)

NEW

7.2W 3 - 12VDC Plugpack Cat. MP-3310 $19.95
Dimensions: 69(L) x 39(W) x 31(H)mm

18W 3 - 12VDC Plugpack Cat. MP-3312 $24.95
Dimensions: 69(L) x 39(W) x 31(H)mm

18W 3 - 12VDC Plugpack Cat. MP-3314 $29.95
Dimensions: 69(L) x 39(W) x 31(H)mm

27W 3 - 12VDC Plugpack Cat. MP-3316 $34.95
Dimensions: 96(L) x 50(W) x 30(H)mm

25W 9 - 24VDC Plugpack Cat. MP-3318 $34.95
Dimensions: 96(L) x 50(W) x 30(H)mm

MASSIVE SAVINGS ON POWERTECH SOLAR PANELS!

These monocrystalline panels are more efficient than polycrystalline panels and are as strong and tough as the better known brands, but at a more attractive price.

- Sizes range from 5 watts to a massive 175 watts.

MASSIVE SAVINGS

	CAT	WAS	NOW	SAVE
12 Volt 5 Watt	ZM-9091	$115.00	$59.95	$55.05
12 Volt 10 Watt	ZM-9093	$175.00	$94.95	$80.05
12 Volt 20 Watt	ZM-9094	$225.00	$149.00	$76.00
12 Volt 65 Watt	ZM-9096	$639.00	$399.00	$240.00
12 Volt 80 Watt	ZM-9097	$875.00	$475.00	$400.00
12 Volt 120 Watt	ZM-9098	$1280.00	$695.00	$585.00
24 Volt 175 Watt	ZM-9099	$1750.00	$1100.00	$650.00

MAINS STANDBY POWER SAVER WITH IR RECEIVER

NEW

Saves on energy bills and reduces your carbon footprint. Eliminates the needless power consumed by appliances when they are in standby. Once it detects that they are in standby mode, it will switch them off completely after a short delay. Switching all your appliances on again is as simple as pressing the on button on the remote control.

- Dimensions: 128(H) x 65(W) x 40(D)mm

$39.95 Cat. MS-6146

SURGE/OVERLOAD PROTECTED POWERBOARDS

Individually switched powerboards provide a high level of protection from overload and surge, with extra-wide spacing to take mains plugpacks. Ideal for home theatre, computers, TV and video or audio systems.

- Extra-wide spacing to take mains plugpacks
- Individually switched
- Surge and overload protected
- 4 or 6 way

NEW

4 Way	Cat. MS-4064	$19.95
6 Way	Cat. MS-4066	$24.95 Due Mid February

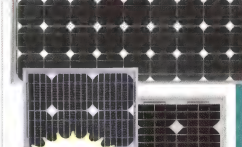
WIRELESS 3-OUTLET MAINS POWER METER

Simply plug an appliance into each sender unit, enter your local electricity price and monitor the usage on the LCD of the receiver unit. You can also monitor the cumulative usage via the memory as well as the greenhouse gas emissions. It also has a clock and alarm function. Receiver requires 3 x AA batteries

Frequency: 433.92MHz
Transmission range: 30m

NEW

$99.95 Cat. MS-6116



SAVE OVER 33% OFF ORRP*!

*Not available in all stores. Please ring your local store before driving across town

VIFA 6.5" WOOFER

A brilliant and versatile driver that can be designed to perform to 40Hz or lower. Features include a cast magnesium basket, mineral filled polycone and smooth frequency response. Ideal for bass reflex enclosures of 10 - 30 litres

- Power handling: 70WRMS
- Nominal impedance: 8 ohms
- Frequency response: 37Hz - 5kHz
- Sensitivity: 88dB SPL @ 1W, 1m

$99.00 Cat: OR-2106

NEW

TWISTED PAIR RCA STEREO AUDIO CABLES

Featuring RFI and EMI noise reduction to keep your car's audio sounding wholesome. This twisted pair RCA cable is made from double aluminium foil and quality copper braid shielding for that accurate sound transfer.

- Plug to Plug
- Split center pin connectors
- Frosted jacket design
- Platinum-plated ends

5 Lengths Available:

0.3m	Cat. WA-1079 $14.95
0.5m	Cat. WA -1071 $14.95
1.5m	Cat. WA-1073 $19.95
2.5m	Cat. WA-1075 $24.95
5.0m	Cat. WA-1077 $29.95

NEW

NEW

TOUCHSCREEN DVD/MULTIMEDIA PLAYER

Comprehensive in-car connectivity - this impressive unit plays all the popular AV formats from just about any portable media or mass storage device. Plus it's Bluetooth-ready for handsfree communication when paired with a Bluetooth enabled mobile phone. It's user-friendly touchscreen menu enables you to easily select and control several input play options. Mounting hardware, Bluetooth bus and remote control included.

- Motorised 7" touchscreen LCD (480 x 234 pixels)
- 22WRMS x 4 channels (45W max each)
- Front panel USB, SD & aux-in
- 1 x rear camera input, 1 x video output

$499.00 Cat: QM-3789

NEW

IN-DASH DVD/MULTIMEDIA PLAYER WITH USB AND BLUETOOTH

A solid all-round performer, this in-car entertainment system plays all the popular multimedia formats and devices. It is Bluetooth hands free ready and comes complete with detachable anti-theft panel with colour LCD display and slimline remote control.

- Front USB port, SD/MMC card slot and aux-in
- PLL tuner with 18 x FM and 12 x AM presets
- DVD+R/RW, CD-R/RW playback
- Supports MP3, JPEG and WMA files
- 4 channels x 20WRMS output (40WRMS max)
- 4-band equaliser (classic, pop, rock, flat)

NEW

$249.00 Cat: QM-3788

LIGHTING

NEW

LED NIGHT LIGHT WITH SENSOR

No need to stub your toe when you get up in the middle of the night. Keep one of these plugged in and it will give you enough light to see where you're going. Operates automatically.

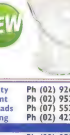
- Rotates through 360° to light any direction
- Automatically comes on in darkness
- Unobtrusive size - smaller than a double adaptor

Due Mid February

$9.95 Cat: ST-3181

LED TORCH KIT

Configure the light in any of three different ways: a hand-held torch, headlamp or a handy lantern. The head torch comes with its own battery pack and head band and the lantern makes the ideal tent light for camping. Lanyard and tripod included.



- Requires 1 x CR123A, 2 x AA batteries
- Output 120lm
- Torch 98/L/mm

$69.95 Cat: ST-3391

NEW

CAR AMPLIFIER WIRING KITS

Complete wiring kits for installing a car amplifier everything you need down to the cable ties and screws. Save $$ on the individual parts. 4G and 8G kits available, see our website for kit contents:

8G Wiring Kit Cat: AA-0442 $59.95
4G Wiring Kit Cat: AA-0444 $99.00

NEW

Bargain of The Month!

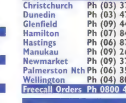
3 WATT LED TACTICAL TORCH

For a limited time only we have secured this 3W LED Tactical Torch ST-3399 for a bargain price. Hurry in while stocks last!

Bulletproof machined aircraft aluminium construction and O-ring sealed for all the rigours of professional work. The tailcap has a tactical switch.

- Requires 3 x AA batteries
- Output: 120 lumens
- Size: 148/L x 34/Diam

Ask for a demo



SAVE $5

$14.95 Cat: ST-3399

Was $19.95

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Springvale	Ph (03) 9547 1022
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Thomastown	Ph (03) 9465 3333
Werribee	Ph (03) 9741 8951

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Jaycar Electronics

Prices valid to 23rd February 2010

Arrival dates of new products in this flyer were confirmed at the time of print. Occasionally these dates change unexpectedly. Please ring your local store to check stock details.

PRODUCT SHOWCASE

Microgram's Intellingent Carousel: 150 CDs on line.

Tired of searching for and organising CD's and DVD's? Microgram's Intelligent Carousel allows up to 150 CDs to be safely stored in a carousel style library – and using the dedicated database software, with five modes of search available, finding a CD, DVD etc only takes a matter of seconds.

It can be controlled via a PC or used as a stand-alone unit using the included CD Manager Index Card. And if 150 discs isn't enough for you, up to 128 units can be interconnected to one PC using USB hubs which gives an incredible 19200 disc capacity. It can store DVD movies, music CDs, game discs (Xbox, PS2, PC etc) as well as data discs.

Contact:
Microgram Computers
PO Box 8202, Tumbi Umbi, NSW 2261
Tel: (02) 1800 625 777 **Fax:** (02) 4389 0234
Website: www.mgram.com.au

Skunkworks hangs the biggest and the best!

With a few exceptions, large plasmas and LCDs remain weighty and therefore a challenge to mount safely. Many people consider large flat panel TV a must-have, however the list of brackets that can be trusted to mount this treasured possession is a small one.

The multi-award winning Skunkworks range of large screen mounting solutions are all about modern living and functionality. Its Vasco series of flat-to-the-wall brackets and extendable arms suit all structural and usage requirements. They are also 'universal', meaning they suit any screen's mounting configuration.

As versatile as they are, there is no compromise on safety or longevity, as each bracket is precision engineered from laser cut steel and its 'footprint' on the wall is substantial, rather than just the one or two points of contact that some brands have.

Contact:
Skunkworks
101 Canning Hwy, East Fremantle 6158
Tel: 1800 241 280 **Fax:** (08) 9339 8810
Website: www.skunkworks.com.au

Chiphacker: a new electronics website

Sydney based boutique electronics retailer Little Bird Electronics has launched the dedicated electronics question-and-answer community website **chiphacker.com**.

Collaboratively built and maintained by electronics enthusiasts, Chiphacker.com connects people to the information they're seeking with those who know it.

Everyone reading this magazine has some experience and knowledge about electronics and Chiphacker.com provides a way for people to share their experience and insight.

With everyone's help, Chiphacker can build good answers to every imaginable electronics question. No matter what level you are at, microcontroller you use (or don't use!), or what programming languages you use – better electronics is chiphacker's goal!

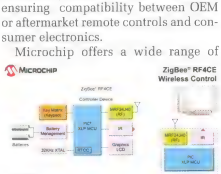
Contact:
Little Bird Electronics
PO Box 127, Berowra NSW 2081
Tel: 0401 252 250 **Fax:** (02) 8569 0339
Website: www.littlebirdelectronics.com

Microchip's ZigBee for wireless remotes

Microchip Technology Inc. has achieved certification for its ZigBee RF4CE Compliant Platform, which enables the next generation of RF remote controls and consumer electronics. The platform consists of Microchip's nanoWatt XLP eXtreme Low Power PIC microcontrollers, the MRF24J40 IEEE 802.15.4 transceivers and modules and the industry's smallest memory footprint ZigBee RF4CE certified protocol stack.

The consumer electronics industry is rapidly changing from infrared remote controls, which require line-of-sight operation and have limited range, to the more versatile RF wireless technology. The ZigBee RF4CE protocol provides an industry standard for this transition, ensuring compatibility between OEM or aftermarket remote controls and consumer electronics.

Microchip offers a wide range of tools for development with the PIC XLP microcontrollers, including the free MPLAB IDE, the MPLAB REAL ICE emulation system, the MPLAB ICD 3 in-circuit debugger, the PICkit 3 low-cost debugger/programmer and Microchip's free C compilers. All of these tools are available at **www.microchip.com/XLPTools**. *SC*



Contact:
Microchip Technology Inc
2355 West Chandler Blvd, Chandler, Az USA
Tel: (0011 1 480) 792 7200
Website: www.microchip.com

Do you occasionally need to measure very low resistances accurately but don't have access to an expensive benchtop Milliohm Meter or DMM? This low-cost adaptor will let you use almost any DMM to make accurate low-resistance measurements.

Milliohm Meter Adaptor for DMMs

By Jim Rowe

When it comes to measuring low resistances (ie, below about 10Ω) with any significant accuracy, very few standard handheld digital multimeters are of much use. Only the top-of-the-range models offer any real performance in this area.

And when you want to measure even lower resistances – less than one ohm – even some of these drop out of contention. It's really only the most expensive benchtop models that will provide milliohm-level measurements as a matter of course.

This doesn't pose much of a problem for most of us, most of the time, because accurate low-value resistance measurements are not needed very often.

But sometimes you do: matching the values of low-value resistors used for current sharing in amplifier output stages, for example, or when you need to make up a low resistance current shunt for a panel meter.

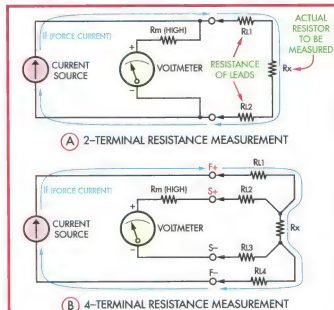
That's when you need this Milliohm Meter Adaptor. It's self-contained and designed to act as a very low resistance measuring 'front end' for almost any standard DMM.

It works by converting low resistance values into a directly proportional DC voltage (nominally 0-1.000V), so the DMM is simply set for its 1V or 2V DC voltage range, the range where most DMMs have their highest accuracy.

So when the adaptor is being used to measure a very low resistance, the resistance value is simply read out on the DMM in millivolts.

Actually the adaptor provides two measurement ranges, one a '0-1.0Ω' range where it converts milliohms directly into millivolts (so 125mΩ becomes 125mV, for example) and the other a '0-10Ω' range where it converts tens of milliohms into millivolts – so 2.2Ω (ie, 2200mΩ) becomes 220mV.

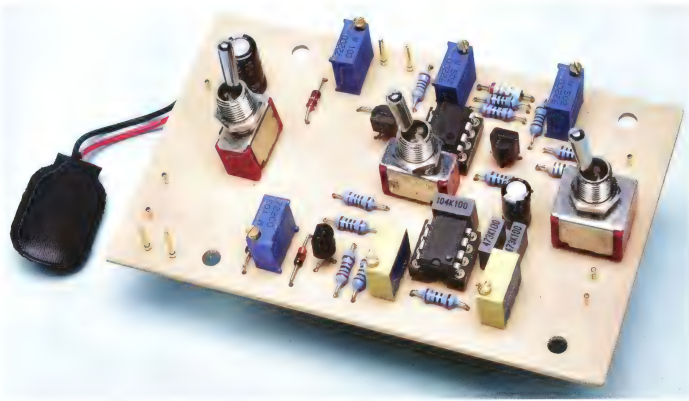
So reading the low value resistances on your DMM doesn't require much mental arithmetic.



The top diagram (Fig.1a) shows the way resistance is measured in "normal" meters (ie, two-terminal). The lower diagram (Fig.1b) shows how higher accuracy is achieved with four-terminal measurement, especially for low resistances. This is the approach taken in this adaptor.

Now at this stage you're probably thinking this: if a low-cost adaptor like the one we're describing here can make this kind of very low resistance measurement relatively easily, why don't most DMMs provide such ranges?

That's because there is a catch: in order to measure low resistances accurately, you have to use a four-terminal measurement approach rather than the two-terminal ap-



With the exception of the terminals and battery, all components mount on the one PC board.

proach used in the majority of DMMs.

Before we look at the new adaptor and the way it works, then, we'd better explain first why it needs to make four-terminal measurements.

Why 4-terminal measurements?

To understand what we're talking about here, look first at the upper resistance measurement circuit in Fig.1(A). This shows the kind of two-terminal measurement used by most DMMs to measure resistances.

As you can see it's quite straightforward: a constant current source forces a current, *If*, through the resistance to be measured (*Rx*), which is connected to the meter's test terminals. The voltmeter section of the DMM then measures the voltage drop across the test terminals, which is directly proportional to the resistance between the terminals – because according to Ohm's law this voltage is given by E = *If* x *Rx*.

Note that the voltmeter has a very high multiplier resistance (*Rm*), so it is assumed to draw virtually no current.

The drawback with this approach is that as shown, our unknown resistance *Rx* isn't the only resistance between the two test terminals – there's also the resistance of the test leads, *RL1* and *RL2*. These are effectively in series with *Rx*, so the voltage drop across them as a result of If flowing through them will simply be added to the drop across *Rx*. The resistance measured by the DMM will therefore be (*Rx* + *RL1* + *RL2*), rather than just *Rx* itself.

Now from a practical point of view this doesn't introduce much error when you're measuring resistances over 10Ω or so (with fairly short test leads). It's usually not too difficult to keep the test lead resistances down to a few tens of milliohms (which is less than 1% of the value of *Rx*). But when you're trying to measure somewhat lower resistances, the errors can be quite significant.

For example, if the resistance you're measuring is 1Ω, two test leads each with a resistance of 30mΩ will increase the total resistance across the terminals by 60mΩ or 0.06Ω, giving a measurement error of +6%.

Now consider what happens when we use the four-terminal measurement approach shown in Fig.1(B). Here we still force a known current through the unknown resistor *Rx* and measure the voltage drop across it as before, using

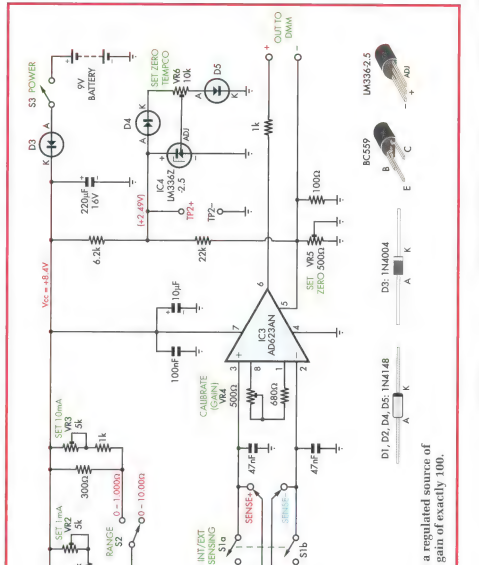


Fig.2: the complete schematic. The circuitry at upper left forms a regulated source of force current, while that at lower right is a DC amplifier with a gain of exactly 100.

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a high resistance voltmeter. But in this case the force current If is fed to *Rx* via one pair of terminals F+ and F-, while the voltmeter is connected across *Rx* via a second set of 'sensing' terminals S+ and S-. As you can see the F+ and S+ terminals are connected to one end of *Rx* via separate leads, while F- and S- terminals are connected to the other end – also via separate leads. So there are now four test leads, with resistances *RL1*, *RL2*, *RL3* and *RL4*.

But how does this extra complexity help?

Look carefully and you'll see that although the force current If still flows through force lead resistances *RL1* and *RL4*, the voltage drops in these resistances now don't matter because the voltmeter's sensing leads are connected directly across *Rx* itself – ie, we now only measure the voltage drop across *Rx* alone.

And the sensing lead resistances *RL2* and *RL3* don't cause any problems either, because they're simply in series with the very high resistance of the voltmeter circuit (and they carry only its tiny measurement current).

So that's why changing over to four-terminal resistance measurement gives much better accuracy, especially when you're measuring very low resistances.

Circuit description

Now that you understand the basic concept of four-terminal resistance measurement, we will look at the circuit of the new Milliohm Measuring Adaptor and the way in works in detail.

The schematic diagram (Fig.2), has four measuring terminals just to the left of centre labelled FORCE+, FORCE-, SENSE+ and SENSE-. It will help in understanding the way the circuit operates if you regard all of the circuitry above and to the left of the force terminals as comprising the force current source, while all of the circuitry to the right of the sensing terminals comprises the voltmeter section. (It's actually a DC amplifier with its output connecting to the voltmeter section of a DMM.)

Before we get going, you've probably noticed already that the two poles of switch S1 are wired so that the two positive terminals and the two negative terminals can be connected together if desired, for 'internal sensing'.

This switch has been provided purely to allow the adaptor to be used for making 'quick and dirty' (ie, less accurate) two-terminal measurements on components which can be connected directly to the force terminals, without any test leads as such.

So for the rest of this discussion you should regard both poles of S1 as 'open', just as they are shown in the schematic. This 'external sensing' position of S1 is the one used for accurate four-terminal measurements, with Rx connected to all four terminals as shown.

Let's turn now to the circuitry used to provide the force current for our measurements. This is the section at upper left of the schematic involving IC1, IC2a and transistor Q1. Although it may look a bit complex, it's really quite straightforward if you break it into sections. IC1 together with D1, D2, the 6.2kΩ resistor and trimpot VR1 form a regulated voltage source which establishes a voltage difference of 2.490V between test points TP1+ (the adaptor's supply rail) and TP1-.

Why 2.490V? Simply because when the LM336-2.5 reference used for IC1 is adjusted to have this voltage drop, the temperature coefficient or 'tempco' of its voltage drop is very close to zero – staying constant over a wide temperature range (0-50°C).

IC2a and Q1 are used together with their associated components to generate a constant force current through the adaptor's force terminals, using the 2.490V voltage drop established by IC1 as its reference. They do this very simply: IC2a increases the base current to Q1 until the voltage level at Q1's emitter (fed to pin 2 of IC2a) matches the voltage level fed to pin 3 by IC1. The base current is then stabilised at this level and this in turn stabilises the transistor's emitter and collector

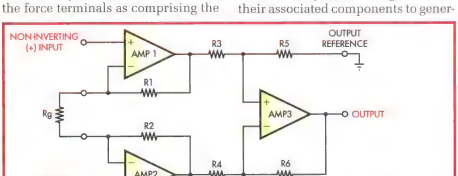


Fig.3: an instrumentation amp consists of three internal op amps, two used as matched input buffers for the third one (AMP3) connected as a difference amp.

Parts List – Milliohm Adaptor for Digital Multimeters

1 PC board, code 04102101, 91x57mm
1 UB3 (130 x 68 x 44mm) utility box
2 8-pin machined pin DIL IC sockets
1 DPDT mini toggle switch (S1)
2 SPDT mini toggle switches (S2, S3)
2 4mm binding posts, red
2 4mm binding posts, black
1 4mm banana jack socket, red,
1 4mm banana jack socket, black
4 15mm long M3 tapped spacers
8 6mm long M3 machine screws
1 9V battery, alkaline or lithium
1 9V battery snap lead
4 self-adhesive rubber feet
12 1mm diam. PC board terminal pins
1 200mm length red insulated light duty hookup wire
1 200mm length black insulated light duty hookup wire

Semiconductors
2 LM336Z-2.5 +2.5V regulators (IC1,IC4)
1 LM358 dual op amp (IC2)
1 AD623AN instrumentation amp (IC3)
1 BC559 PNP transistor (Q1)
4 1N4148 100mA diodes (D1,D2,D4,D5)
1 1N4004 1A diode (D3)

Capacitors
1 220µF 16V RB electrolytic
1 10µF 16V RB electrolytic
1 100nF 100V MKT metallised polyester
2 47nF 100V MKT metallised polyester

Resistors (0.25W 1% unless specified)

1 27kΩ	1 22kΩ	2 6.2kΩ
1 2.7kΩ	4 1kΩ	1 680Ω
1 300Ω	1 100Ω	1 68Ω

2 10kΩ 25t vertical trimpot (code 103) (VR1,VR6)
2 5kΩ 25t vertical trimpot (code 502) (VR2,VR3)
2 500Ω 25t vertical trimpot (code 501) (VR4,VR5)

currents as well.

Since the voltage level at the emitter of Q1 is set by the current flowing in the resistance between the emitter and the positive supply rail, we can set the force current level by adjusting the emitter resistance.

We provide the adaptor with two measuring ranges by using switch S2 and the various resistors in Q1's emitter circuit to provide two different preset emitter resistances, corresponding to two preset force current levels.

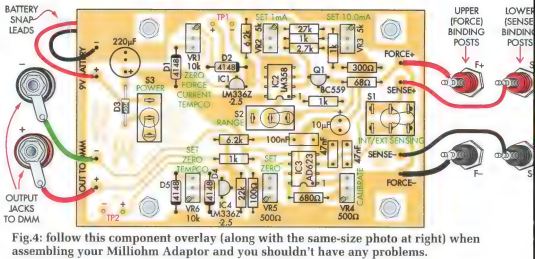


Fig.4: follow this component overlay (along with the same-size photo at right) when assembling your Milliohm Adaptor and you shouldn't have any problems.

For example when S2 is in the position shown, the transistor's emitter resistance consists of the fixed 2.7kΩ, 1kΩ and 27kΩ resistors together with trimpot VR2. By adjusting VR2 we are thus able to set the total effective emitter resistance to 2.490kΩ, which sets the collector current of Q1 (ie, the force current) to a level of 2.49V/2.49kΩ, or exactly 1.000mA.

Alternatively if S2 is switched to the '0-1.000Ω' position, the 300Ω and 1kΩ fixed resistors plus trimpot VR3 are connected in parallel with the existing emitter resistances, and by adjusting VR3 we are now able to set the total effective emitter resistance to 249.0Ω. This sets the collector current of Q1 to a level of 2.49V/249Ω, or exactly 10.00mA.

So switch S2 allows us to set the adaptor's force current level to either 1.000mA or 10.00mA, and that's how we provide its two measuring ranges.

As mentioned earlier, the section of the circuit to the right of the sensing terminals (SENSE+ and SENSE-) acts as a DC amplifier which takes the small voltage drop across our unknown resistor Rx (produced by the force current flowing through it) and amplifies it before feeding it out to the DMM for measurement.

We use an AD623AN instrumentation amp (IC3) for this job, because the requirements are fairly stringent: we need high and stable DC gain (100 times) coupled with high input impedance, very low input offset and high 'common mode rejection'. These requirements are most easily met by using an instrumentation amp like the AD623AN.

By the way if you're not familiar with instrumentation amps, a simplified version of their most common internal configuration is shown in Fig.3.

As you can see they consist of three conventional op amps, with the third one (AMP3) operating as a difference amplifier.

The other two amps are configured as input buffers, to give each input of AMP3 a high input impedance. At the same time the gain of the two input buffers is carefully matched by laser trimming of their feedback resistors R1 and R2. This matching is also done for the resistors around AMP3, and the end result is not only very low input offset but very high common mode rejection as well.

Because of the balanced nature of the two input buffers their gain (and that of the complete instrumentation amp) can be set by varying a single external resistor, Rg.

Note that although the 'output reference' terminal of AMP3 in Fig.2 is shown as earthed, we use this connection of the AD623AN in the main circuit to allow fine zero adjustment of IC3.

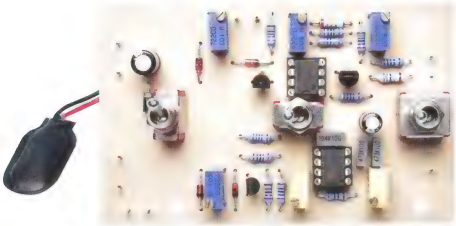
The 680Ω fixed resistor and trimpot VR4 connected between pins 1 and 8 of IC3 are used to adjust the gain of the amplifier stage to exactly 100 times (ie, they correspond to Rg in Fig.2). As a result VR4 is used to calibrate the adaptor/DMM combination for the most accurate readings.

As yet we haven't mentioned IC4 – which as you have probably noticed already is a second LM336Z-2.5 voltage reference, just like IC1.

It's also connected in the same way as IC1, with diodes D4 and D5 plus trimpot VR6 used to allow its voltage drop to be set to 2.490V – providing a near-zero temperature coefficient. So its function is to provide a temperature stabilised source of +2.490V (with respect to ground in this case),

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	27kΩ	red violet orange brown	red violet black red brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	2	6.2kΩ	blue red red brown	blue red black brown brown
❑	1	2.7kΩ	red violet red brown	red violet black brown brown
❑	4	1kΩ	brown black red brown	brown black black brown brown
❑	1	680Ω	blue grey brown brown	blue grey black black brown
❑	1	300Ω	orange black brown brown	orange black black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	1	68Ω	blue grey black brown	blue grey black gold brown



The two sets of "horizontal" PC pins at the top centre and bottom left of the PC board are test points, not normally connected.

measurable between test points TP2+ and TP2-.

Why do we need another source of stabilised DC voltage? Because although the AD623AN instrumentation amp is particularly good in terms of very low input offset, like all components in the real world it isn't perfect.

So in order to set the output to the DMM to exactly 0.000V when IC3 has zero input voltage (ie, when the SENSE+ and SENSE- terminals are shorted together and also connected to ground), we need to vary the DC voltage connected to pin 5 of IC3 over a very small range relative to circuit ground.

That's the purpose of trimpot VR5, which forms the lower leg (together with the 100Ω resistor across it) of a voltage divider connected across the stabilised 2.490V source provided by IC4. The upper leg of the divider is the 22kΩ resistor, so by adjusting VR5 we are able to vary the voltage level at pin 5 of IC3 between 0V and approximately +10mV. This may seem small, but it's quite sufficient to allow setting the adaptor's output to zero – within a tiny fraction of a millivolt.

As you can see the complete adaptor circuit operates from a single 9V alkaline battery, with switch S3 used to control power and diode D3 to prevent circuit damage in the event of the battery being connected with reversed polarity. This means that all of the adaptor operates from the unregulated +8.4V (nominal) supply rail. We can do this because IC1 and IC4 stabilise the only critical reference voltages.

Incidentally, the battery drain of the adaptor when operating on the 0-1.000Ω range is around 14mA, dropping to around 4mA on the 0-10.00Ω range. The difference is of course due to the change in force current level.

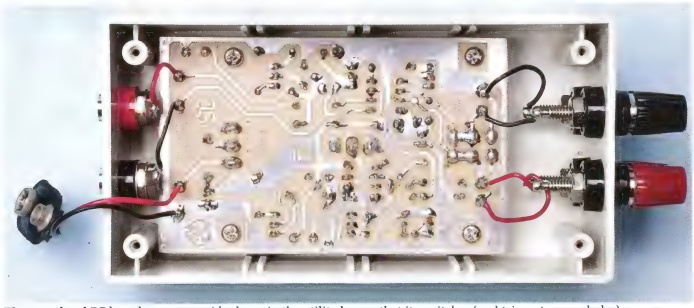
Construction

As you can see from the photos, the adaptor is housed together with its 9V battery in a standard UB3 size jiffy box (130 x 68 x 44mm). Inside the box, all of the components apart from the measurement terminals and output sockets are mounted directly on a small PC board, coded 04102101 and measuring 91 x 57mm.

The PC board is supported inside the box using four 15mm long M3 tapped spacers. The four measurement terminals are mounted in one end of the box, while the two output sockets are mounted in the other end.

Although there is a reasonable number of components on the board, assembly should be quite easy if you use the overlay diagram and internal photos as a guide. There are no wire links to be fitted but there are 12 PC board terminal pins – four for the two pairs of test points and the other eight for the off-board connections to the measurement terminals, output sockets and battery snap lead wires.

Fit these pins first, taking care to fit the test point pins from the component side of the board and the other pins from the copper side. This makes it easier to connect to the latter pins after the board assembly is fitted into



The completed PC board mounts upside-down in the utility box so that its switches (and trimpot access holes) emerge through the bottom of the case – which with the addition of a suitable label becomes the front panel. The box lid, with adhesive rubber feet, then becomes the base of the project. (See also Fig.6, overleaf).

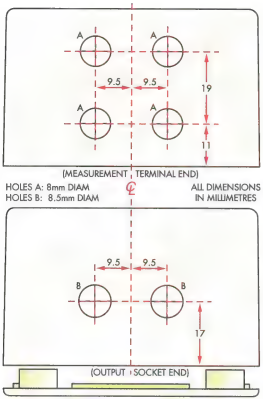


Fig.5: drilling detail for the two ends of the UB3 utility box. You will also need to drill nine holes in the "bottom" of the box – use a photocopy or printout of the front panel artwork (Fig.7 overleaf) as a drilling template.

the box.

After the terminal pins are fitted and soldered in place, you can fit the sockets for IC2 and IC3. Follow these with the three mini toggle switches, as you may need to use a small needle file to convert the matching holes in the board into a rectangular shape to accommodate the connection tags on the rear of the switches. The tags of each switch need to pass down through the board holes as far as they'll go, before soldering to the pads underneath.

With all three switches fitted, the next components to add are the fixed resistors. Make sure you fit these in their correct positions as shown in the overlay diagram, because otherwise you adaptor may not work correctly. If necessary, use your DMM to check the value of each resistor before it's fitted in place and soldered.

Follow the fixed resistors with the five capacitors. Three are of the unpolarised MKT metallised polyester type and the remaining two of the polarised electrolytic type. Make sure you fit these two with the polarity shown in the overlay diagram.

Next fit the trimpots, which are all of the miniature multi-turn type with their adjustment shaft in one top corner. Be careful in fitting these, not only to fit the correct value pot in each position (there are two 10kΩ pots, two 5kΩ pots and two 500Ω pots) but also to make sure that each pot is orientated the correct way around as shown in the overlay diagram. VR1, VR2 and VR3 are orientated with their adjustment shaft at upper right, while the other three trimpots have the opposite orientation with the adjustment shaft at lower left.

If you don't mount them this way you won't be able to adjust them easily when the board assembly is mounted inside the box.

The final components to fit to the board are the semiconductors, starting with five diodes. Take care to fit them the correct way around. Note too that D3 is a 1N4004 diode rated at 1A, while the others are smaller 1N4148 diodes.

After the diodes are in place, fit transistor Q1 and the two TO-92 voltage reference ICs, IC1 and IC4, again watching their orientation. Your board assembly will then be complete, apart from the two plug-in ICs.

We suggest that you only plug in IC2 at this stage. IC3 is best left out until the initial setting up has been done, because it's a fairly expensive chip and could possibly be damaged before the force current levels have been set correctly.

For the moment just place the nearly completed board assembly aside while you prepare the box by drilling the various holes that are needed.

There are no holes to be drilled in the box lid, as this is used purely as a screw-on base for this project. All of the 'works' is mounted inside the box proper, as you can see from the photos and the side view assembly diagram.

There are several holes to be drilled in the box bottom, as this becomes the Adaptor's top/front panel. A photocopy of the front panel artwork (or a printout of the panel artwork file from **siliconchip.com.au**) can be used as a template for locating and drilling these holes. The small holes should all be 3.5mm diameter, while the three larger holes (for the switch ferrules) should all be 7mm diameter.

The location and sizes of the holes in the ends of the box are shown in

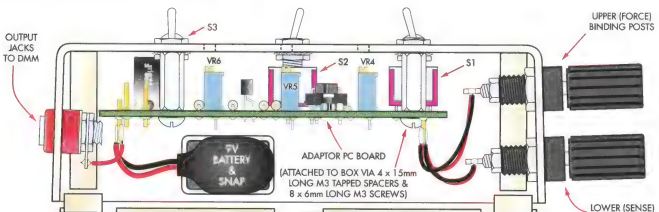


Fig.6: this "X-ray" view through the utility box side shows how it all goes together. Not seen here are the two red binding posts which, are directly behind the black posts. The 9V battery could be mounted in its own holder or, if you want to save a couple of dollars, do as we did – simply hold it in place with some Gaffer or duct tape!

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the diagram of Fig.5. Once these holes have been drilled (and if necessary reamed to size), you can fit the measurement terminals and the output jack sockets into them, taking care to tighten their nuts firmly so they won't come loose in use.

Before your Adaptor's PC board assembly can be fitted into the completed box, it needs to have some of its initial setup adjustments made. These are done with the PC board assembly on the bench, and powered by either its own 9V battery or a suitable 9V mains power supply.

Initial setup adjustments

All of the adjustments can be made using a standard DMM, which can be the one you'll be using the Adaptor with later, if you wish.

The first adjustments to be made are of the two temperature coefficient zero pots VR1 and VR6, and for both of these adjustments you use the DMM set to its 0-4V, 0-10V or 0-20V DC range. To adjust VR1, you simply connect the DMM test leads to test points TP1+ and TP1- and then adjust VR1 with a small screwdriver until you get a reading of 2.490V (or as close to this figure as you can get). This done, you can transfer the DMM leads to TP2+ and TP2- and now adjust VR6 in the same way, to get a reading of 2.490V.

This completes the first two adjustments, and you'll be ready to make the next two. For these the DMM is switched to its low DC current ranges and this time its leads are connected to the FORCE+ and FORCE- terminal pins on the right-hand end of the board – with the positive lead connected to FORCE+ and the negative lead to FORCE-.

Switch S2 with its toggle towards the right (ie, in the 0-10.00Ω position), and your DMM should give a current reading somewhere in the vicinity of 1mA. Change the DMM's range if necessary to provide the best possible resolution, and then adjust trimpot VR2 until you get a reading as close as possible to 1.000mA (= 1000µA).

Once this has been achieved switch S2 to its other position (0-1.0Ω), which should cause the current reading to jump to a higher figure – around 10mA. Again adjust the DMM range if necessary to get optimum reading resolution and then adjust trimpot VR3 to bring the reading as close as possible to 10.00mA.

That will complete the initial setup adjustments and you're almost ready to fit the PC board assembly inside the box. Turn off the power with S3 and then remove the 9V battery from its snap lead. Attach the four 15mm x M3 tapped spacers to the top of the board using four 6mm long M3 screws passing up from underneath. Tighten the screws firmly to make sure they don't become loose later.

Now take IC3 from its protective packaging and plug it carefully into its socket at lower right on the board, making sure that it's orientated as shown in the overlay diagram.

Final assembly

To begin the final stage of assembly, remove the upper mounting nut from each of the three toggle switches S1-S3 and then adjust the lower nuts to bring the lockwasher and flat washer on each ferrule up to a level as close to 15mm above the top of the board as you can – that is, level with the tops of the four board mounting spacers. You might find a small steel rule helpful here.

Now, with the upper nuts still off the switch ferrules, the idea is to hold the PC board assembly upright while you lower the main part of the Adaptor's box down over it (with the correct orientation, of course!) until the switch toggles and then the tops of their threaded ferrules pass up through their matching holes in the box.

They should be protruding by about 1.5-2mm by the time the tops of the mounting spacers are up against the upper inside of the box, allowing you to attach the three remaining switch nuts to each switch ferrule to hold everything together. Then you'll be able to fit the four remaining 6mm long M3 screws to secure the board mounting spacers to the box as well.

The screws should be tightened quite firmly, whereas the switch nuts need only be 'finger tight'.

The final step in assembling your Milliohm Adaptor is to upend the box and fit the short connecting wires which connect the measurement binding posts and output sockets to their corresponding terminal pins on the PC board. The connections for each of these wires is shown in the overlay/wiring diagram, so if you follow this methodically you shouldn't make any mistakes.

By the way there's no need to use heavy-gauge wire for any of these wires – ordinary insulated hookup wire is fine, because of the four-terminal measurement system.

Once these wires have all been fitted, you can mount the Adaptor's 9V battery on the inside lid/bottom of the box, securing it in place with either a small aluminium clamp bracket or a short length of 'gaffer' tape.

Then the snap lead can be reconnected to the battery after making sure that power switch S3 is in the 'off' position and finally the lid/base can be attached to the main part of the box using the four self-tapping screws provided.

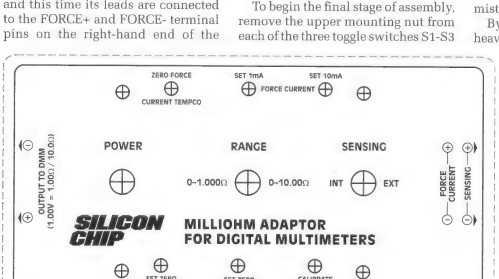

Fig.7: same-size front panel artwork. This can be photocopied (or printed out from the file on www.siliconchip.com.au) and preferably laminated before glueing onto the UB3 box base. First, though, drill the three switch holes and six pot access holes.

Final setup

Your Milliohm Adaptor is

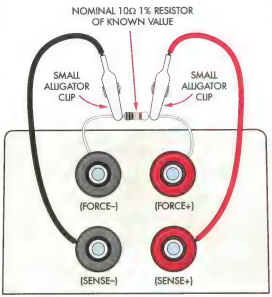

Fig.8: use this test jig to set up your Milliohm Adaptor, as described in the text below

now complete and ready for its final setup adjustments. To prepare for these connect your DMM's test leads to the Adaptor's output jacks, using whatever lead(s) will ultimately be used to connect the two and with the correct polarity.

Then switch on power to the DMM and switch it to a low DC voltage range – whichever range allows you to read voltage up to a bit over 1.000V with the best possible resolution. This will be the same range you'll be using when the Adaptor is ultimately being used with the DMM, of course.

Before you turn on power to the Adaptor itself using S3, first connect BOTH of the Adaptor's S+ and S- binding posts to the F- binding post, using short lengths of tinned copper wire. Next make sure that switch S1 is in the EXT sensing position (toggle to the right) and also that there is NO connection to the Adaptor's F+ binding post because it should be left unconnected for this next adjustment.

When you switch on power to the Adaptor using S3, you'll very likely get a very small but significant reading on the DMM – a few millivolts, in all probability.

The idea is to reduce this reading to zero (or as close as you can get) using a small screwdriver to adjust trimpot VR5 via its matching adjustment hole in the top of the box (at lower centre). You'll find that if you adjust VR5 one way the DMM reading will increase, while if you adjust it the other way it will decrease. So setting the correct 'zero' position is quite easy.

After this there will now be only one further setup adjustment to make: the correct setting for gain trimpot VR4, so that the Adaptor and DMM combination will give accurate low resistance readings.

To prepare for this final adjustment switch off the Adaptor's power using S3 and then remove the wires that were previously used to connect the S+ and S- binding posts to the F- binding post for the zero adjustment.

Then take a 1% tolerance (or better) metal film resistor with a known value of close to 10.00Ω (measured with your own DMM, perhaps, or ideally with another DMM of higher accuracy), and connect the ends of its leads to the upper binding posts of the Adaptor (F+ and F-). Then use a pair of short clipleads to connect the innermost point on each of the resistor's leads to the corresponding sensing binding post, as shown in Fig.8.

Now make sure that switch S1 is in the EXT sensing position and also that range switch S2 is in the 0-10.0Ω position (toggle to the right). Then switch on the Adaptor's power switch S3.

You should see a reading of around 1.000V on the DMM, corresponding to the resistor's value converted using the factor 1mV/10mΩ.

All that you now need to do is adjust trimpot VR4 using a small screwdriver until the DMM reading corresponds to the known value of your nominal 10Ω resistor. Your Milliohm Adaptor will then be set up, calibrated and ready for use.

Using it

Putting the Adaptor to use is quite easy. It's simply connected up to the DMM as it was for the final setup adjustments and with the DMM set for the same low voltage DC range (to give the best measurement resolution). Then you connect the low-value resistor to be measured to all four binding posts, as for the final setting up adjustment.

You can either connect the resistor as shown in Fig.8, or use four separate clipleads if the resistor can't be brought up to the force current binding posts.

To make the measurement, you simply make sure that S1 is in the EXT sensing position and that S2 is set for the more appropriate measurement range (ie, either 0-1.000Ω or 0-10.00Ω, depending on the resistor's value).

Then switch on power using S3 and the DMM reading will show the unknown resistor's measured value – in millivolts, and with a scaling factor of either 1mV/1mΩ or 1mV/10mΩ depending on the range you're using.

So using the Adaptor to make four-terminal measurements of low value resistors is really pretty easy, isn't it?

As mentioned earlier though, it can also be used to make 'quick and dirty' (ie, less accurate) two-terminal measurements, if you're in a hurry and accuracy isn't all that important.

To make two-terminal measurements, all you need to do is switch S1 to the INT sensing position and connect the resistor to be measured only to the F+ and F- binding posts – ideally with the shortest practical lead lengths.

Then when you turn on the Adaptor, the DMM will give you a 'pretty close' reading of your unknown resistor's value. SC

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Internet Time Display Module

. . . a simple add-on for the Web Server In a Box (WIB) to show local time

By MAURO GRASSI

Looking for a really accurate clock? This simple add-on board for the WIB (Web Server In A Box) displays the time and date, as gathered from an internet time server. You can use it as a clock you never need to adjust and it can even be configured in the WIB to automatically adjust for daylight saving time.

IN THE NOVEMBER & December 2009 issues of SILICON CHIP, we published the WIB (Web Server In a Box), an ethernet-based web server with a memory card. This simple add-on board allows the time and date to be displayed on a 7-segment 4-digit LED display. The time is gathered from the internet and is re-synchronised every 10 minutes by the WIB for update on the display.

In operation, the time and date information gathered by the WIB is sent to the add-on module via the on-board serial port. The hours, minutes, seconds, day, month and year can all be displayed. A single pushbutton switch allows you to scroll through the time and date readings or you can set the unit to automatically scroll through the time and date displays.

Circuit operation

Take a look now at the circuit diagram of Fig.1. It's based on a single microcontroller (IC1), in this case a PIC18F1320. Apart from that, there's just the four 7-segment LED displays, 12 transistors to drive the displays and a handful of minor parts.

To keep the cost down, an 8MHz RC oscillator internal to IC1 is used as the system clock. Its accuracy is quite sufficient for our purposes – it really only affects the baud rate of the UART (universal asynchronous

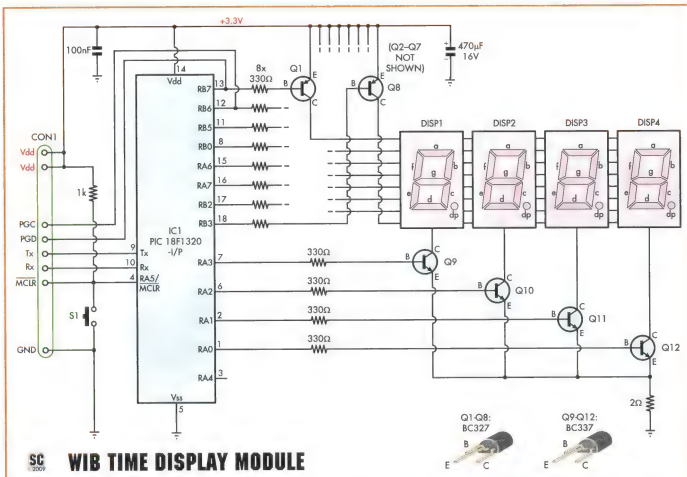

Fig.1: the circuit uses microcontroller IC1 to process the serial data from the WIB PC board. IC1 then drives four 7-segment LED displays in multiplex fashion via switching transistors Q1-Q12.

receiver/transmitter) used to receive the time and date information from the WIB and in any case, the baud rate is synchronised automatically to the baud rate of the UART in the WIB (more on this later).

In operation, IC1 receives the time and date information on its Rx pin (pin 10). This data is then processed by the internal firmware and IC1 then drives the 7-segment LED displays (DISP1-4) in multiplex fashion via switching transistors Q1-Q12.

The 7-segment LED displays each have a common cathode and these are driven (one at a time) by the RA3-RA0 outputs of IC1 via NPN transistors Q9-Q12. A single 2Ω resistor is used to limit the peak current through the displays. This needs to be substantial to obtain reasonable brightness.

The 330Ω resistors provide base current limiting for the transistors.

By contrast, the corresponding anodes of each display digit are connected together and these are driven by IC1 via PNP transistors Q1-Q8. Transistors Q1-Q7 drive the segments, while Q8 drives the decimal point.

Switch S1 is used to scroll between the time and date displays and to select the display mode. Normally, pin 4 (RA5/MCLR-bar) of IC1 is pulled high via a 1kΩ resistor but each time S1 is pressed, pin 4 is pulled low.

A short press, ie, less than 1s, scrolls to the next display, while a long press (longer than 1s) is used to change the display mode. This is described in greater detail later in the article.

Power for the circuit is derived from the +3.3V rail on the WIB board and is fed via connector CON1. A 470µF electrolytic capacitor and a 100nF monolithic capacitor provide supply decoupling for the module.

The PGC, PGD and MCLR-bar lines are used only for programming the PIC microcontroller, if necessary. These inputs are all made available on CON1, as are the power supply and receive (Rx) connections. A transmit output

WIB Time Display Module: Main Features

- Displays local time and date derived from an internet time server
- Can be configured in the WIB to automatically adjust to daylight saving time
- Six different display modes for time and date (including static and scrolling displays)
- Three line interface to the WIB with automatic baud rate adjustment
- Persistent settings (settings stored in EEPROM)

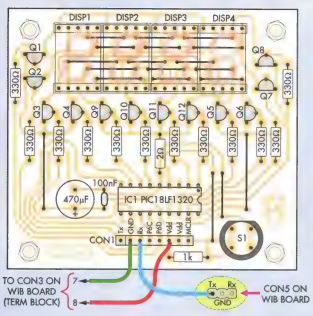

Fig.2: all the parts are assembled on a single PC board measuring 76 x 69mm. Take care with the orientation of switch S1 and the microcontroller and be sure to use the correct transistor type at each location.

Parts List

1 PC board, code 07102101, 76 x 69mm
1 piece of red Perspex, 51 x 18mm
4 M3 x 25mm Nylon screws
4 M3 x 12mm Nylon spacers
4 M3 Nylon nuts
1 18-pin IC socket
2 20-pin IC socket strips or 1 x 40-pin IC socket (to be cut in half)
1 SPST PC-mount momentary switch (Jaycar SP-0721, Altronics S-1096)
1 0.5m-length of 0.7mm tinned copper wire (for links)

Semiconductors

1 PIC18F1320-I/P microcontroller programmed with 0710210A.hex (IC1)
8 BC327 PNP transistors (Q1-Q8)
4 BC337 NPN transistors (Q9-Q12)
4 7-segment red common cathode LED displays (Jaycar ZD-1855, Altronics Z-0190)

Capacitors

1 470µF 16V electrolytic
1 100nF monolithic

Resistors (0.25W, 1%)

1 1kΩ
1 2Ω
12 330Ω

from the microcontroller has also been made available but is unused in this application.

Firmware overview

The firmware scans the pushbutton switch (S1), debounces it and differentiates between a short and a long press. It also listens for activity on the serial port.

In operation, the time and date are sent by the WIB (when the time module is enabled) as a packet of bytes. Note that the time module in the WIB must be enabled via the SNTP set-up page, as shown in Fig.5 (ie, in the default website supplied with the WIB).

The baud rate is gathered automatically from a synchronisation header in the packet. This means that the module will work with any serial port baud rate of between 600 and 115,200 bps (although even higher speeds will work).

When the firmware receives a packet, it will display it according to the currently set display mode. There are seven display modes in total, as outlined below and switch S1 is used to select between them.

Note that any settings made using S1 are persistent, ie, they are stored in EEPROM and are retained if the power is switched off. These settings include the display mode, whether the time is displayed in 12 or 24-hour format, and the order in which the day and month are displayed. These are preferences that can vary according to locality but the default values are good for Australia.

Building it

The WIB Time Display Module is built on a single-sided PC board coded 07102101 and measuring 76 x 69mm. Fig.2 shows the assembly details.

Before starting the construction, you should inspect the board for defects, including shorts between tracks and open circuit tracks. That done, you can begin by installing the 19 wire links. Many of these go under the LED displays, so it's vital that they go in first.

You can use 0.7mm (or similar) tinned copper wire for the links. These links should all be nice and straight, so that they don't short together. If necessary, you can straighten the link wire by clamping one end in a vice and then stretching it slightly by pulling on the other end with a pair of pliers.

Once the links are in, you can move on to the resistors. There are just three different values and you should refer to the resistor colour codes in Table 1 to distinguish between them. You should also check them using a digital multimeter, just to make sure.

Make sure that the correct value is installed at each location.

Next, the eight BC327 PNP transistors can be soldered in place. These are transistors Q1-Q4 on the left and

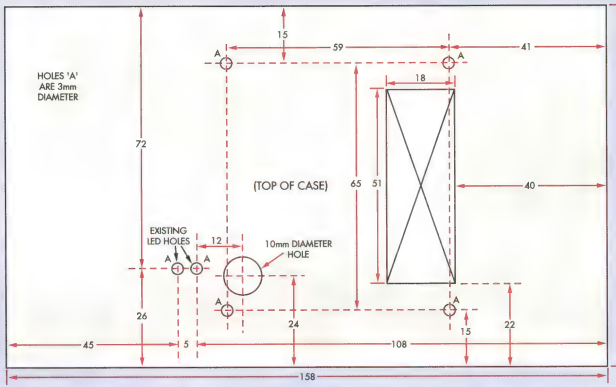

Fig.3: the drilling and cutout diagram for the lid of the case. The display cutout can be made by drilling a series of holes around the inside perimeter, then knocking out the centre piece and filing to a smooth finish.

Q5-Q8 on the right. They will only go in one way but be sure to install them in the correct locations.

Once these are in, you can install the four BC337 NPN transistors. These are transistors Q9-Q12 and they are located just below DISP2 and DISP3.

The next thing to do is to solder in the socket for IC1. Note that the notch must match the component overlay shown in Fig.2.

If you are building the WIB Time Display Module from a kit, the microcontroller will be supplied pre-programmed. If not you will need to program it with the firmware file 0710210A.hex which can be downloaded from the SILICON CHIP website.

Once programmed, install IC1 in its socket with the correct orientation.

Mounting the displays

The four 7-segment LED displays are mounted by plugging them into two 20-pin socket strips. You can either use SIL pin socket strips for this job or you can cut a 40-pin IC socket into two 20-pin strips.

Once the pin strips are in, plug the four displays in with their decimal points are at bottom right. Be sure to push each display down as far as it will go and make sure that all the pins go into the sockets.

Switch S1 is next on the list. It must be installed with the flat side of its body oriented as shown in Fig.2. The assembly can then be completed by installing the two capacitors and

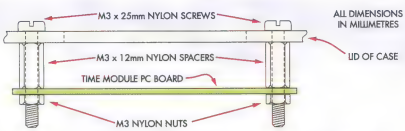

Fig.4: this cross-sectional diagram shows how the WIB Time Display Module is secured to the lid of the case. It's mounted on four M3 x 12mm Nylon spacers and secured using M3 x 25mm Nylon screws.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	12	330Ω	orange orange brown brown	orange orange black black brown
❑	1	2Ω	red black gold gold	red black black silver brown

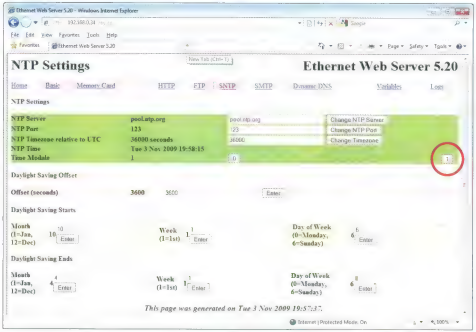

Fig.5: in order for the clock to work, you have to enter in the settings for a valid NTP server in the NTP Settings page of the default website supplied with the WIB. You also have to enable the Time Module by clicking the "1" button (circled in red).

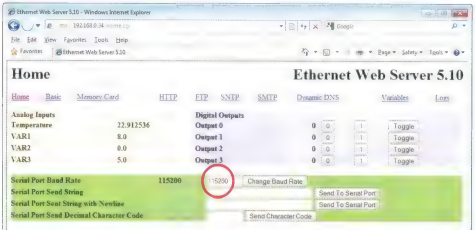

Fig.6: the default Serial Port Baud Rate of 115200 (circled) can be left as it is on the Home page of the default website but just about any value between 600 and 115,200 bps can be used as the display module automatically synchronises to the baud rate.

8-way socket connector CON1.

Take care with the orientation of the 470µF capacitor.

Connecting it to the WIB

As shown in Fig.2, only three leads are required to connect the Time Display Module to the WIB PC board. The +3.3V (Vdd) and GND (ground) connection can be picked up at the screw terminal blocks, while the Rx connection must be connected to the Tx (UART transmit) output pin on CON5 of the WIB.

You can either make the connections to CON1 & CON5 by soldering the leads to the underside of the PC boards or you can plug the leads directly into the sockets and apply a small amount of solder to secure them.

Because of the higher current consumption when the display module is connected, you will need a higher-rated plugpack than the one originally specified in the November 2009 article. In that article, we specified a 6-9V 300mA plugpack but you should make that a 6-9V 500mA plugpack if you are using the WIB Time Display Module as well.

The existing regulator on the WIB board will cope with the increased current without problems, although it will run warmer.

Boxing it

The completed PC board can either be mounted in a separate case or it can be installed in the WIB case. If you choose the latter, then you will have to drill some additional holes in the lid and make a cutout for the LED displays.

Fig.4 shows the drilling details for the lid. You can make the display cutout by drilling a series of holes around the inside perimeter of the marked area, then knocking out the centre piece and filing the job to a smooth finish.

Once the holes have been drilled, the module can be mounted in position on four M3 x 12mm Nylon spacers and secured using M3 x 25mm Nylon screws – see Fig.4. That done, test fit the two halves of the case together without the end pieces and check that there is adequate clearance between the two boards (ie, no shorts).

If everything is correct, the case can then be fully assembled and the lid secured in place using the self-tapping screws supplied. A 51 x 18mm piece of red Perspex can be pushed into the display cutout to give a good finish. A couple of dabs of epoxy adhesive on the edges will hold it in place.

The red Perspex diffuses the light and makes the digits look uniform in brightness.

Auto baud rate detection

As stated previously, the firmware in the WIB Time Display Module uses automatic baud rate detection. This means that the module will work with most serial port baud rates between 600 and 115,200 bps.

Make sure, however, that the time data is being sent out by the WIB. This is done by enabling it in the SNTP window of the default website supplied with the WIB (and downloadable

from the SILICON CHIP website).

Basically, you have to enter in the settings for a valid NTP server as described on pages 90-91 of the December 2009 issue. You then have to turn on the Time Module by clicking the "1" button (circled on Fig.5).

Timeout display

In normal operation, the WIB sends out data packets containing the current time and date to the Time Display Module via the serial port. However, if the Time Display Module does not receive a packet during the timeout period (about 3s), it will change its display to four dashes and a periodically blinking decimal point.

This means that the time module does not have valid time and date data to display. This can occur when the Time Module function is disabled in the WIB.

A timeout can also occur if the UART baud rate in the WIB is suddenly changed (ie, on the home page of the supplied website). In this case, the Time Display Module will initially show the timeout display described above. However, it will then automatically adjust to the new baud rate within a matter of seconds and again begin displaying the correct time.

Display modes

Before applying power to the unit, check the board carefully for incorrect parts placement and missed solder joints. Once you are satisfied that all is OK, apply power to the WIB and check the display. The unit should initially show the timeout display (four dashes) but should then begin displaying the correct time once the WIB has booted up and accessed an Internet time server.

The default display is 24-hour time (hours and minutes) but this can be altered, as explained below.

As stated previously, S1 is used to change the display readings and the mode of operation. The circuit responds to two types of button presses – a short press of less than 1s and a long press of greater than 1s.

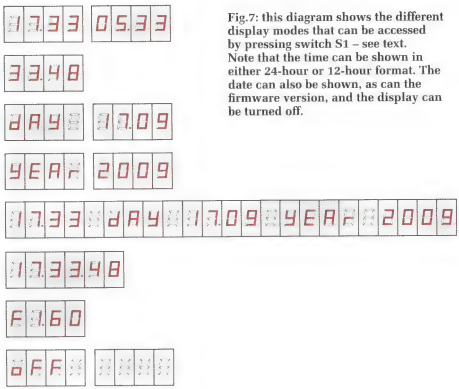

Fig.7: this diagram shows the different display modes that can be accessed by pressing switch S1 – see text. Note that the time can be shown in either 24-hour or 12-hour format. The date can also be shown, as can the firmware version, and the display can be turned off.

A short press always takes you to the next display reading, ie, from hours and minutes to minutes and seconds and then to the day and month and then to the year and so on.

Let's take a closer look at the different display reading and modes:

Mode 1: time in either 24-hour or 12-hour mode, consisting of the hour and minutes with a decimal point between them blinking at 2Hz.

Mode 2: time in minutes and seconds format, with a decimal point blinking at 1Hz.

Mode 3: the date in either **day.month** or **month.day** format, together with a periodically blinking display showing the word **day**.

Mode 4: the year as a 4-digit number, together with a periodically blinking display showing the word **year**.

Mode 5: the time and date shown as a continuously scrolling string.

Mode 6: the time, including the hour, minutes and seconds, shown as a continuously scrolling string.

Mode 7: the firmware version shown as an "F" followed by the 3-digit version number (useful for debugging).

Mode 8: Off (the display is not driven).

Long button presses

A long button press gives a different display mode, depending on the display mode that you are already in. These are as follows:

(1) In Mode 1, it toggles the 24-hour mode on and off.

(2) In Mode 2, it takes you back to Mode 1.

(3) In Mode 3, it toggles whether the date is shown as **day.month** (eg, for Australia) or **month.day** (eg, for the US).

In Modes 4-8, long button presses are ignored. SC

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The Redback Portable PA is ideal for clubs, gynasiums & demonstrations. Rugged, durable and lightweight! Designed to endure the punishment of every day use. Great for hire companies, schools, auctioneers etc. Employing an industrial strength extruded aluminium enclosure with hard wearing powder coat finish. It is fitted with wheels and extendible handle for ease of mobility. This allows systems to be tailored to individual needs. An in-built Class D amplifier exhibits very high efficiency for increased battery life & reduce system weight. Up to 8 hours use from a fully charged battery! In-built top hat allows easy mounting to speaker stands. **See website for more information on this versatile portable sound system.**

SAVE UP TO $671

Rear panel & cover.

$1400
C 7176AS Handheld RRP $2047
C 7176AT Beltpack RRP $2071

Super Special Package Price!

Includes: • C 7176A Portable PA with UHF receiver & CD player. • C 7164 protective cover. • C 8872C UHF handheld OR C 8875C UHF beltpack & C 8907 lapel mic.

Keyring Stud Finder

Makes picture hanging a breeze! Seeks out the nearest solid beam in any wall without the guess work. Requires 2 x S 5014 batteries (S2.05ea).

$3.50
T 4500
RRP $4.95

Star LED Driver Transformer

Provides a constant current source suitable for powering up to six 1W star LEDs. Epoxy encapsulated. 9-30V DC 350mA input.

$15
M 3310A
RRP $16.40

Massive Audio Savings!

2-Way Bookshelf Speakers With Amp

Great for the study or games room. Complete in-built amplifier & speaker combination. No amp required! Employing a 5.25" kevlar woofer & soft dome tweeter in a compact ported enclosure. Wood cabinets produce a rich, full sound, with polished 'piano black' finish. Internal 30W RMS amp, 3.5mm input, RCA output. Sold in a matching pair. 180x255x220mm. 5kg.

$299 C 5050 RRP $399

SAVE $100

Portable Mini Speaker System

Now you can listen to music anywhere! Great for picnics, camping or music at your bedside table. Unique design suits almost any MP3 player or CD walkman! Powered by 4 x AAA batteries. *Plus unit included.

$19 X 0880 RRP $29.95

Add Sensational Sound To Your Lounge Room!

Top quality sound from a compact & stylish design. Can be inverted for mounting on the ceiling for a stylish corner hi-fi speaker. The 6.5" mid/bass driver and silk dome tweeter together produce a crisp frequency response with deep bass for realistic cinema effects. 50W RMS output. Sold in matching pair. Size: 330W x 500H x 220D.

$49 pr C 5250 RRP $149

SAVE $100!

HALF PRICE!

$164 pr C 1017 RRP $328

High Power Wall Speakers

Affordable stylish hi-fi speakers, ideal for any music install. Great for games rooms & entertainment areas! Stunning tuned enclosures employing 2 x 4" midbass drivers & 20mm titanium dome tweeter. 75W rated. Includes aluminium mounting bracket & stainless steel hardware. 80 310x175x216mm. **Sold in pairs.**

Connect It Up...

2.4GHz Wireless AV Sender

Great for wireless CCTV applications. The easy cable-free way to transmit stereo audio & composite video up to 30m. It also relays infra-red allowing you to control equipment remotely. Includes transmitter, receiver and plugpacks.

$59 S 9300A RRP $69.95

4 Way Stereo Line Selector

Switch multiple sources between a single input on your amp/mixer. Ideal for when you've run out of inputs!

$14 A 2036 RRP $19.95

Add a phono input to your AV receiver

Allows you to connect a turntable to a standard line level input. 9V battery powered or use M 9237A plugpack ($17.95) with M 9191 tip ($1.30).

SAVE 35%

$15 A 3050 RRP $22.95

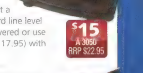
Compact RF Modulator

Converts a composite video & stereo audio signal into a RF coax output. Ideal for distributing AV signals. VHF ch 0/1. Requires M 9272A 12V 0.5A $17.95.

$10 S 9251 RRP $14.95

RF Modulator

Allows you to distribute composite video & stereo audio signals using coaxial cable. Standard PAL RF aerial connection with quick selector switch. VHF channel 1.



$19 S 9233A RRP $28.70

Windows® Multimedia PC Remote Control

Combines functions for DVD, TV tuner, web browser, mouse & keyboard and more. Includes USB infra-red receiver which relays signals to your PC. Slimline case fits perfectly in your hand, great for browsing the web on your TV. Requires 2 x AAA batteries. **Note:** to properly take advantage of this remote, your PC should be Windows® Media Player equipped. However, many functions, including mouse & keyboard control, operate on any XP® or Vista® PC.

$40 D 2401 RRP $49.95

1080p Compatible!

Remote Control HDMI / Digital Audio Switcher

High performance, comercial grade 4 way HDMI switcher. Includes digital audio (both toslink and coaxial) connections for high end AV distribution. An in-built enhancing circuit ensures excellent signal quality, even across long cable runs. RS-232 connection is provided for switching via control console or PC.

$115 A 3083 Was $359

SAVE $244

DISCOUNT Mounting Brackets

BELOW COST CLEAR OUT!

2 For $30 H 8108 Ceiling H 8107 Wall RRP $69

Got an old telly you want to put up in the spare room for the kids? Or use as a security monitor? These compact steel brackets are just what you need! Mount speaker boxes, televisions up to 20" (51cm) or other equipment to the wall or ceiling (wall mount pictured). 35kg max.

In-Ear Bud Earphones

- Superb sound
- Excellent noise reduction
- No tangle retractable cord, 3.5mm plug.

$10 C 5006 RRP $16.95

Great for any MP3 player!

6 In 1 Universal Remote Control

Pre-programmed & infra-red learning. Ideal way to clear that coffee table clutter and combine all your remotes into one easy to use unit. Also great for replacing lost remotes.

$15 A 1017 RRP $19.95

Long Distance Wallplate Baluns

Send audio and video signals over cheap Cat5e/6 cable - Up to 100m! Ideal for sending signals from your study to the lounge. Composite video with stereo audio or component video with digital audio. **Clipsal2000 wallplates.** Sold individually - two required to form a link.

2 For $90 A 3230 Component RRP $103.90

2 For $70 A 3227 Composite RRP $80.90

Reclaim your desk space!

SAVE OVER 15%

$49 H 8181 RRP $59.90

Wall mount your LCD monitor and regain work space! Fully adjustable swing arm. Great for the office, study, kitchen, bedroom, theatre etc. 75 & 100mm mounting holes. 15kg max.

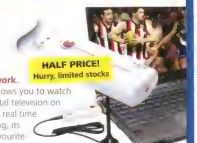
BARGAIN White XLR Leads

10m length with hard wearing, white sheath and top quality metal 3 pin XLR connectors.

That's half price! $9.95 P 0745 RRP $19.95

WOW! Digital HDTV On Your Computer.

Watch while you work. This tiny USB stick allows you to watch **high definition** digital television on your computer. With real time digital video recording, its easy to view your favourite shows anytime you like. • Includes remote control, antenna & aerial adaptor • Software to suit Windows 2000 (SP4) / XP (SP2) / Vista included • Requirements: 2GHz PC with 512mb RAM, USB2.0, 32mb video card. *Laptop for illustration purposes



HALF PRICE! Hurry, limited stocks

$62.50 D 5005A RRP $125

Stereo Multimedia Headset

Great for gaming, VoIP & internet messaging! Includes a pair of super comfortable adjustable headphones and a flex boom dynamic microphone. 2 x 3.5mm jack connection, includes 6.35mm adaptors.

$19 C 9058 RRP $29.95

35% OFF!

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Hurry, Stocks Strictly Limited!

Home Video Door Intercom

See who's at the door before opening it! A safe and easy way to monitor your front door. Kit includes power supply, hookup cable, indoor base station and camera unit. Coupled with a door strike (available separately) you can even remotely unlatch your front door/gate to let visitors in. Can be expanded to 2 indoor stations and 2 cameras. Black & white.

- Extra indoor unit **S 9414A** $119
- Extra camera **S 9415A** $69

$149
S 9413A
RRP $179

SAVE $30

Keyless Entry for Your Home or Business

Interfaces with most alarm systems and door strikes to provide easy access for authorised users by simply waving a coded tag in front of the wallbox. Can be configured to require tag only entry or a combination of tag and PIN security. **Features:** 3 relay outputs • 12V operation • RFID tags sold separately. $9.15 (S 5376). Credit card style tags $3.95 (S 5375)

$75
S 5374
RRP $129

High Resolution Colour Dome Cameras

SAVE UP TO $76

Sony Super-HAD CCD sensor. Designed for high grade installations requiring picture quality 'a step above' the rest. 0.15 Lux. 1/2AD x 100mm. 550 line resolution. Available in 3.6mm fixed-focal length or 3.7-12mm vari-focal. Requires 12VDC supply (M 9272A $17.95).

$199
S 9125 Fixed
RRP $295

$249
S 9127 Vari Focal
RRP $325

$22
S 9128
RRP $24.95

Add-On A Wall Mount Bracket... ...for a professional looking finish. Constructed from heavy duty diecast aluminium & steel. Suits S 9125/7/8.

Vandal Resistant Dome Camera With IR Illumination

Ideal for mounting in exposed locations where damage may occur such as car parks and entrances. Adjustable angle. Excellent night time performance with infra red LEDs. Great for commercial installs. 0 Lux. 420 line colour CCD sensor. Requires 12VDC supply (M 9272A $17.95).

Tough diecast casing!

$129
S 9126A
RRP $159

Turn a DMM into an AC Clampmeter

Simply plugs into standard test lead inputs. Measure AC currents up to 300A without direct contact with live wires. 1mV AC per 0.1A AC. Cat II 600V

Limited Stocks.

BARGAIN!

$15
Q 0850
RRP $22.50

20% OFF Micron® Handheld Soldering Irons

GREAT PERFORMERS UNDER $20!

GREAT VALUE!

Great for enthusiasts & home handymen or as a back up in the toolbox. Includes mini bench stand. Equipped with an iron clad, chrome plated tip.

$17
T 2405 60W
RRP $21.40

$14
T 2405 40W
RRP $16.95

$10
T 2401 20W
RRP $13.95

SAVE 30%

$22
T 1598
RRP $31.95

With in-built wire strippers & cutters!

Deluxe Modular Crimper

Rugged steel construction **designed to last a lifetime.** Suits 6 and 8 way modular connectors. Great for making custom data & telephone leads.

$89
Q 1742
RRP $119

Instant Insulation Testing

An essential for testing electrical circuit "leakage" paths and insulation breakdown. Perfect for electricians or anyone who works on mains equipment. 200MΩ/m, 2000MΩ-0-1000V. Includes holster & test leads.

Contact Free Digital Thermometer

...with laser guided beam for pin point accuracy! Lightweight, "point and shoot" temperature measurement. Provides accurate temperature readings from a distance. Ideal for measurement in dangerous places, or when equipment is operating. Incredible accuracy from -30°C to 550°C.

$69
Q 1790
RRP $99.95

14pc Ratchet Driver Set

Handy ratchet action speeds up any job. Designed for comms equipment, computers etc. Includes 3 phillips, 2 hex nut drivers, 3 flat blade, 4 star bits & extension bar.

$17
T 2180
RRP $21.95

SAVE 30%

$10
T 2785
RRP $14.95

Circlip Pliers

Remove & insert circlips with ease. Suits 8 to 25mm external circlips. 90° hardened steel pegs.

Lab Power & More...

15A 4.5-16VDC Power Supply

SAVE 18%

This compact, fan cooled, switchmode power supply delivers up to a huge 15A regulated output, adjustable between 4.5 and 16V. It's great for powering comms equipment & scanners. 155x55x165mm.

$139
M 8260A
RRP $171

25A 4-16VDC Power Supply

SAVE $60

With auxiliary car accessory socket! Low noise design for communications equipment. Adjustable voltage & noise offset 4-16VDC 22A continuous, 25A max.126x100x180mm.

$169
M 8262
RRP $229

45A 4-16VDC Power Supply

SAVE $81

With auxiliary car accessory socket! Massive 45A capacity for high current draw equipment such as comm's gear, car audio, portable appliances etc. Adjustable voltage & noise offset. 4-16VDC 40A continuous, 45A max. 172x65x200mm.

$229
M 8264
RRP $310

A Revolution In Battery Maintenance Charging

SAVE 40%

A 5 stage charger utilising a microprocessor ensuring battery retains in optimum condition. Automatically diagnoses battery state of charge and delivers an appropriate current. • Also recovers batteries with slightly sulphated plates • Operates in sub-zero temperatures • Suitable for permanent connection • Weatherproof case • Suits sealed lead acid batteries (SLA), wet cells, gel cell and AGM batteries from 1.2Ah to 120Ah • Supplied with plug-gable croc clips and ring terminals • 14.4V @ 3.8A • Size: 175x60x45mm.

$50
M 8530
RRP $94.95

Ideal for the seldom used car, caravan or boat!

Charge your laptop in the car!

These compact supplies simply plug into your cars accessory socket and provides regulated power to a laptop. Selectable output voltages 15, 16, 18, 19, 20, 22 and 24VDC, up to 6A. Supplied with 6 adaptors to suit most laptops.

$40
M 8827
RRP $59.95

Super Fast NiMH Battery Charger

Dead flat to 100% in 30 mins!

Charge 4 x AA or AAA batteries in just 30 MINUTES! Ultra fast portable battery charger designed for in-car use. Includes accessory socket lead. Fan cooled. Requires M 8935 power supply if powering from 240V mains.

$27
A 0294
RRP $31.95

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If you are dissatisfied with our goods for any reason, return to our premises within 14 days for a full refund (less transport costs). Returned items must be in NEW condition with all packaging and instructions.

D-I-Y Projects...

Digital-Analog Converter Kit

(SC Sept-Nov '09) This professional quality kit can drastically improve the sound output from your DVD player, allowing you to obtain audiophile quality sound from a regular CD/DVD player, set-top box, PVR or computer. Also reduces buzz, hum and signal noise, ensuring your listening experience is top notch. Coaxial or optical inputs. RCA output. 240V mains operation. **Includes screened and punch rack case, all components, transformer, PCB's and cabling.**

Audiophile quality stereo sound at a fraction of the cost!

$299 K 5332 NEW KIT!

Reduce Unwanted Noise & Vibration On Boats.

Motor boat engine speed matching kit (SC Nov '09)

This module can dramatically reduce vibration & noise by ensuring the RPM of each engine is matched. It reads the frequency signals from each engine tacho and displays RPM difference up to 200RPM on an analog gauge showing **Includes meter.**

$48.95 K 0220 NEW KIT!

Digital Megohm Meter Kit

(SC October '09). **New updated digital version of a kit favourite!** Ideally suited for checking insulation breakdown in electrical wiring, transformers, automotive generators and alternators. 500V or 1000V range. Reads up to 999MΩ and leakage currents to below 1µA. Requires 4xAA batteries.

$79.95 K 2598 NEW KIT!

Web Server In A Box (WIB) Kit

(SC Nov '09) Host and update your own website without the need for a computer! This compact box houses a chip based server that may be accessed anywhere in the world - even from a mobile phone. Beyond serving web pages it can also monitor and log four analog inputs, or control four digital outputs for remote activation of devices.

$89.95 K 6276 NEW KIT!

Great for remote monitoring & control

100W Class AB Amp Module Kit

(SC March '00)

2 for $100 K 5150 RRP $99.95ea

Add these parts to your order to build up your new stereo amplifier

K 5155 Power supply Kit $42.95

M 5535 35VA 15+15 transformer $47

M 4912A 36VA 12+12 transformer $28.95

Build up an ultra low distortion stereo amp for superb hi-fi performance!

Remote Control Your PC!

(SC Aug' 03) Provides remote control of Winamp and WinDVD software as well as a host of other PC automation abilities. A 1013 remote control to suit 536.80

$20 K 2725 RRP $29.95

Bass Display Kit

(SC Feb '01) Displays 4 VU level meters ranging from 32Hz to 16GHz. See what frequencies your subwoofer really gets down to!

$25 K 5418 RRP $39.95

Speaker Level Meter Kit

Easy to use!

(SC April '04) Lets you adjust home theatre or car audio systems with precision, ensuring the correct level for each speaker.

$20 K 2552 RRP $34.45

Subwoofer Processor Kit

(SC Sept 99) Get the most out of your subwoofer. Designed to compensate for poor subwoofer response or improve bottom end. It can even reduce speaker cone travel! Features a subsonic filter set to 20Hz, variable low pass filter, variable gain, plus dual phase outputs. Requires 15V DC power supply.

$22 K 5559 RRP $32.95

GREAT VALUE!

Never leave your car lights on again!

(SC Aug '01) Headlight Reminder Kit. This useful kit emits an alarm whenever you leave the lights on & open your car door. Don't get caught with a flat battery again! Easily connects to most vehicles

$20 K 4249 RRP $31

Great for older cars!

Monitor Your 240V Power Usage

Find out what its REALLY costing you to run your appliances!

(SC July 04) This energy meter allows you to keep a keen eye on every electron you use! It simply connects inline with your appliances and provides usage figures in both kilowatt hours (kWh) or dollars. Great way to budget energy within the home or business and reduce operating costs! Also protects from brownouts.

$129 K 6330 RRP $149.50

16 Second Message Recorder

(SC Feb '94) Self contained audio recording and playback module. Records messages for alarms, displays & monitoring systems etc Requires 6VDC.

$50 K 3570 RRP $68.95

Resellers

WESTERN AUSTRALIA

Esperance	Esperance Communications	9071 3244
Geraldton	ML Communications	9965 7555

QUEENSLAND

Brisbane South	Dalsound Pty Ltd	3397 8155
Brisbane North	Prime Electronic Components	3352 7466
Capalaba	Leading Edge Electronics	3245 0000
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Gladstone	Leading Edge Electronics	4972 6660
Gold Coast	Prime Electronics	5531 2599
Gympie	Leading Edge Electronics	5483 6677
Hervey Bay	Leading Edge Electronics	4124 1490
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Kingaroy	South Burnett Computers	4160 4800
Longreach	Access Electronics	4658 0500
Maryborough	Leading Edge Electronics	4121 4559
Mossman	Leading Edge Electronics	4098 2200
Rockhampton	Access Electronics	4922 1058
Toowoomba	Michaels Electronics	4632 9990
Townsville	Solex	4771 4211
Yeppoon	Keppel Electronics	4939 1555

VICTORIA

Ballan	Radcomp	5368 1761
Beaconsfield	Electronic Connections	9768 9420
Benalla	North East Electronics	5762 2710
Castlemaine	Top End Technology	5472 1700
Clayton	Rockby Electronics	9562 8559
Cranbourne	Bourne Superstore	5996 2755
Croydon	Truscott's Electronics	9723 3860
Geelong	Academy TV	5248 1621
Horsham	Leading Edge Electronics	5382 4150
Leongatha	Gardner Electronics	5662 2861
Leongatha	Leongatha Photographics & Elect.	5662 3227
Melton	Tandy Electronics	9743 1233
Nunawading	Semtronics	9873 3555
Pakenham	Gel Smart Hi-Fi & Repairs	5941 4886
Portland	PR Electronics	5521 1121
Preston	Preston Electronics	9484 0191
Swan Hill	Latens Communications	5032 2322
Warrnambool	Koroit Street Electronics Services	5561 5111
Wodonga	Exact Computers and Electronics	6056 5746

NEW SOUTH WALES

Brookvale	Brookvale Electrical	9938 4299
Cobar	Cobar Electronics	6836 2962
Deniliquin	Wired Entertainment	5881 5555
Forster	Powerpoint Electronics	6554 5006
Griffith	Griffith Systems Plus	6964 5933
Gunnedah	Protronics	6742 2110
Muswellbrook	Leading Edge Electronics	6543 1904
Newcastle West	Henchman Products	4956 7111
North Richmond	CPT - Candle Power Technology	4571 4699
Orange	Forday Electronics	6362 0991
Parramatta	Ironics Business Solutions	9630 9330
Penrith	Penrith Light and Sound	4722 2223
Port Macquarie	John Fehl Two Way Radio	6581 1341
Raymond Terrace	Leading Edge Electronics	4987 4909
Smithfield	Chantronics	9609 7218
Tamworth	Bourke St Electronics	6766 4664
Tuna	Powerpoint Electronics	6557 8000
Ulladulla	Leading Edge Electronics	4454 5588
Wagga Wagga	Wagga Car Radio & Hi-Fi	6925 6111
Waterloo	Henkes Electrical	9319 3133
Wetherill Park	Techtron Electronics	9604 9710
Windang	Mad Electronics	4297 7373
Wyong	Pro Disc Entertainment	4353 1100

SOUTH AUSTRALIA

Adelaide	Aztronics	8212 6212
Brighton	Force Electronics	8377 0512
Enfield	Aztronics	8349 8340
Findon	Force Electronics	8347 1188
Mt Barker	Force Electronics	8391 1133

TASMANIA

Hobart	Active Electronics	6231 0111
Launceston	Active Electronics	6334 7333

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VISA

GPS Car Computer

Part 2 - by Geoff Graham

Last month, we introduced our new GPS Car Computer and provided full constructional details. But there's a lot more that we haven't covered yet . . .

First of all, we'd better run through some of the functions of the GPS Car Computer for those who might have missed last issue. To build the GPS Car Computer you will, of course, need to refer to that issue.

Operation

In operation the GPS Car Computer is easy to use. There are seven "screens" that can be displayed and you can step through these screens with the UP and DOWN buttons.

All screens have something that can be configured. For example, on the speedometer you can set the over-speed alarm and on the clock screen you can set the time zone. To change a setting you press the SET button and then use the UP/DOWN buttons to adjust the value. Pressing the SET button a second time will save the value and return to the main display.

Rather than manually press the UP/DOWN buttons to show a new screen you can put the unit into "Auto Scan" mode. Here the display will automatically flip from one screen to the next every three seconds. When it reaches the end it will wrap around and continue on from the beginning.

To enter Auto Scan mode you simultaneously press both the UP and DOWN buttons. To exit this mode press any button.

To reduce the number of screens on show you can configure the unit to hide some of them. To set this up you must hold down the UP button when you apply power. This will put the unit into a mode where you can set the following characteristics for each screen;

- Show.
- Hide in auto scan.
- Always hide.

The latter is useful if, for example, you have not connected the unit to a fuel injector solenoid and do not want to see the Fuel Economy display. When set to "Always Hide" that screen will be skipped as if it did not exist.

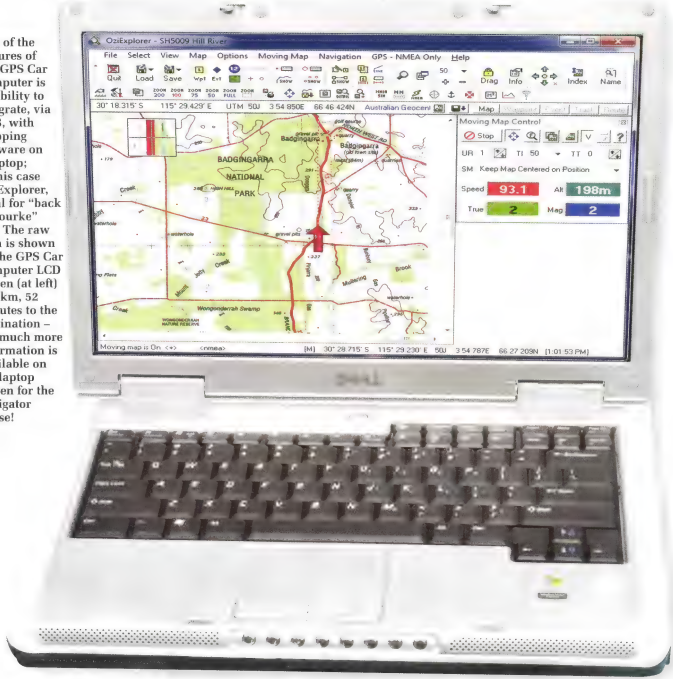
The "hide in auto scan" setting is useful if you want to hide some screens during the Auto Scan mode but still have them available when you manually step through the screens.

A good example is the "Signal Levels" screen which you would not normally need to see.

While in this mode pressing the SET button will step you through the three settings described above and the UP and DOWN buttons will move you through the list of screens available for configuration.

To exit this mode you simply remove and reapply the power.

All settings including the currently showing screen are



One of the features of our GPS Car Computer is its ability to integrate, via USB, with mapping software on a laptop; in this case OziExplorer, ideal for "back 'o'Bourke" use. The raw data is shown on the GPS Car Computer LCD screen (at left) – 93km, 52 minutes to the destination – but much more information is available on the laptop screen for the navigator to use!

automatically saved in non-volatile memory and restored on power-up.

Data Display

Most of the displayed data comes from the GPS module; it provides speed, time, heading, altitude, latitude/longitude and signal levels. Other displayed data is calculated internally by the microcontroller. The GPS will put out fresh data every second so this is the update frequency adopted by the microcontroller.

The speed reading is averaged internally by the GPS module so that the numbers do not jump around with signal noise.

As a result it will take a few seconds for the speedometer to settle down. The other readouts update much faster.

The distance and time-to-destination is calculated by taking the speed every second and working out the distance travelled during that second. This is then subtracted from the total distance to the destination and the result displayed.

While not as accurate as a GPS with in-built maps, it does give a good indication.

This function has two main uses. It is handy when you

Three of the more common displays you'll use on the GPS Car Computer. At left is the speedo, arguably quite a bit more accurate than the one on your dashboard! Centre is the distance and time to destination and at right, relative fuel economy.

need to drive along a road for a certain distance to reach a defined point (eg, "drive for 15km then turn left").

It is also useful when you need to count down a larger distance. For example, the next town might be 200km away and you are planning to stop there for lunch. This function will then show you how much longer you will have to put up with hunger pains!

The time-to-destination is calculated by taking into account your average speed over the last 10 minutes. So, if you get stuck behind a slow-moving truck you can expect to see the time before lunch increase accordingly.

This function is also handy for children who continuously ask "How much longer Daddy?"

Economy meter

The fuel economy meter is another function that is calculated internally by the microcontroller. While it sounds complex it is quite simple to implement.

The microcontroller monitors the percentage of time that a fuel injector solenoid is opened in any second. That, combined with the vehicle speed over the same second, is used to calculate the amount of fuel used per kilometre driven.

This assumes that the pressure in the fuel line to the solenoid remains relatively constant and that all solenoids for all cylinders open for the same amount of time.

For this purpose these assumptions are close enough and the upshot is that the percentage that the solenoid is open is directly proportional to the amount of fuel consumed by the vehicle.

The result is displayed as a bar graph. A longer bar means that you are consuming more fuel per kilometre than a shorter bar. You can adjust the full-scale sensitivity to suit your car and preferences.

When driving you should try and keep the bar as short as possible. You will find that during acceleration from a standstill the consumption will shoot off the scale. Not much can be done about this because you are consuming a large amount of fuel for only a small (zero) distance travelled.

At cruising speed the graph will sit in the middle of the scale and you can vary it markedly depending on your driving habits.

Computer interface

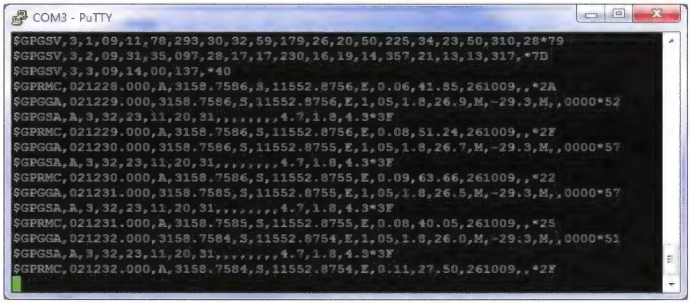
The USB interface allows you to connect to any computer with a USB interface. In this mode the GPS Car Computer implements a subset of the NMEA-0183 standard for interfacing marine electronic devices as defined by the USA based National Marine Electronics Association (NMEA). This is an almost-universal standard and most software will communicate seamlessly.

If you search on the internet you will find a wealth of software that will allow you to navigate, log your movements, play with the GPS module and much more. We will only cover a few here but you can check **www.maps-gps-info.com/fgpfw.html** where over 450 free GPS-related programs are listed.

While you are using the USB interface the GPS Car Computer Display will continue to operate as normal, showing speed, heading, etc. So it is possible for the driver to have whatever data is of interest showing, while a passenger can be separately using a laptop for navigation or other GPS related functions.

Before you can use the GPS Car Computer with your computer you must install the appropriate device driver. This can be downloaded from the SILICON CHIP website where it is listed as "Silicon Chip USB Serial Port Driver.zip". The driver will work with Windows 2000, XP, Vista and Windows 7 in 32-bit mode and Vista/Win7 in 64-bit mode. It uses the standard CDC serial interface supplied by Microsoft with all modern versions of Windows and there are also Linux versions available on the Internet.

The USB standard says that all USB devices must have a unique combination of two 16-bit numbers - the Vendor ID (VID) and Product ID (PID). When you plug in a USB device the first thing it does is send its VID and PID to your computer, which in turn uses them to locate the correct device driver. If you did not use a unique VID/PID you could have confusion where, for example, your computer might try to



This screenshot of the PuTTY terminal emulator program gives a good idea of what the data stream received over the USB interface would look like. The format of the data meets the NMEA-0183 standard which is a universal communications format used by most GPS related software.

Here's a screenshot of the BSGPS software using a map downloaded from the OpenStreetMap project and live data from the GPS Car Computer. You can see that we are travelling up Bland St approaching Birdwood Ave – not bad for software and maps that cost nothing.

load the device driver for an Apple iPod.

Manufactures can purchase a Vendor ID (VID) from the USB standards body and then use whatever Product ID (PID) numbers that they need in combination with the VID to differentiate their products. Rather than purchase a whole VID for this project we sublicensed a single PID from Microchip for use with their corporate VID. These two numbers are used by the GPS Car Computer and the USB Serial Port Device Driver and ensure that our gadget is legally correct.

Driver installation

After downloading the driver you should unzip the files into a temporary folder. The method of installing the software varies between versions of Windows but essentially, when you plug the GPS Car Computer into an USB port the operating system will prompt for a driver. You should then point it to the temporary folder and install from there.

If, for some reason, you are not prompted to install the driver you can navigate to Device Manager and you should see an entry under Other Devices called "SC GPS Display". Right click on that and select Update Driver Software. You can then direct the operating system to the temporary folder.

After you have successfully installed the driver you should see the GPS Display listed in Device Manager under Ports (COM and LPT) as "Communications Port - Silicon Chip USB Serial Port". Take note of the COM port number allocated by the operating system, you will need this when configuring software to work with the GPS Car Computer.

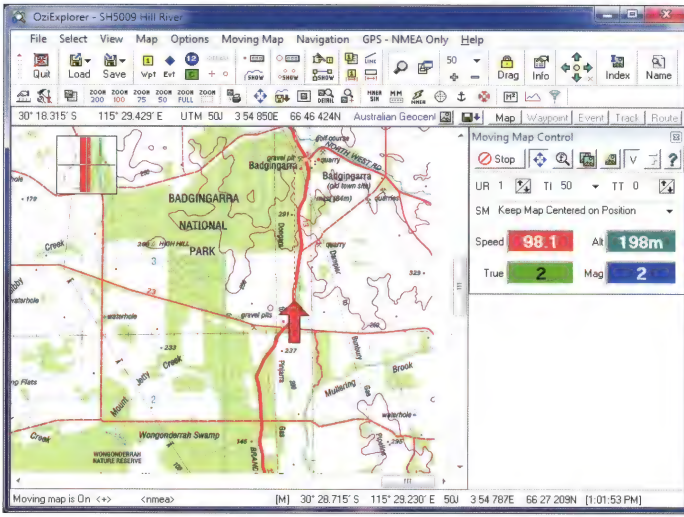
In this mode the GPS Car Computer appears as a virtual serial port in the operating system. You can use any serial terminal emulator such as Hyperterminal, PuTTY, RealTerm or Hercules Terminal Emulator to access the data. When you run the emulator and configure it for the correct COM number you should see the data streaming from the GPS module. The screenshot of the PuTTY terminal software gives a good example of what you can expect.

Note that when setting the COM port number the baud rate and other settings are ignored – the USB Serial Port always runs at the highest speed it can.

A good utility for testing the interface is "NMEA Monitor" (http://homepage2.nifty.com/k8/gps). This will show you the raw data as well as decode the NMEA sentences and will give you a better insight to what is going on.

Using NMEA Monitor or a terminal emulator you can also send commands to the GPS module. You should be careful here as the microcontroller in the GPS Car Computer expects that the module will be in the normal factory default mode and it may not work if you have changed things too much. In particular, you must be careful not to change the baud rate. The GPS module communicates with the microcontroller at 4800 baud and if you change this nothing will work, including your USB serial interface, even if you remove and reapply power.

If you have screwed up the GPS module you can try press-



Here's a larger view of the OziExplorer software shown on the laptop earlier, with a high resolution HEMA map. Position and heading is shown on the map as a red arrow with the tip pinpointing our exact position. This is live data using the GPS Car Computer. The map will move as the vehicle travels keeping our current position in the centre. The software also shows our speed (98.1Kmh) and altitude (198m).

ing the Down Button while plugging the GPS Car Computer into power. This will cause the microcontroller to send a reset command to the GPS module and may recover the situation, although it is not guaranteed.

Navigation software

The most impressive use of the computer interface is with navigation software running on a laptop. With it you can get a moving map, with your position pinpointed exactly.

It is worth noting that this is different from the normal GPS units that you can purchase such as the TomTom or Garmin devices. These are optimised for city driving and, as a consequence, are focused on taking you to a certain place rather than telling you where you are. In addition the accuracy of their maps is very poor once you get into rural areas.

This is no good for country travellers and in particular 4WD drivers who are navigating across country following little used roads or tracks. In this case you want to see your exact position on a detailed and accurate map. You certainly do not need to be told when to turn right or left as intersections are far between and generally obvious, when you come to them.

A typical software package for this type of navigation is OziExplorer with the HEMA map package for Australia (**oziexplorer.com** and **hemamaps.com.au**). Both of these will load onto your Windows based laptop and combined will give you the equivalent of a detailed printed map.

The GPS Car Computer works fine with this type of software and the result is that your exact location will be pinpointed on a high accuracy map with a scale of 250 metres per millimetre (depending on the maps that you bought).

The HEMA maps are rather expensive so OziExplorer allows you to scan in your own maps but you still have to buy the software. A number of lower cost alternatives exist and a good example is BSGPS (**bettersoftware.co.uk**) which is essentially free (they ask for a donation). This software also allows you to scan your maps so you can continue to keep the cost low.

If you mostly keep to the more populated areas you can use BSGPS with the OpenStreetMap project (**openstreetmap.org**). This is a free editable map of the world and contains reasonable detail for urban locations. Using BSGPS you can download the sections that you are interested in and have a very low cost navigation solution.

If you have Internet access on your laptop (perhaps difficult in the bush but not impossible!) you could use the GPS Car Computer with Google Earth to dynamically download and display maps. You could even have your position plot-

Loading New Firmware

The GPS Car Computer includes a small program which is called a bootloader. This enables you to reprogram (sometimes called "flashing") the microcontroller using nothing more than a normal Windows computer with an USB port.

To make it easy for us the GPS Car Computer pretends to be a Microchip PICDEM FS USB board when it is in the bootload mode. That means we can program it using software developed by Microchip to program their own products.

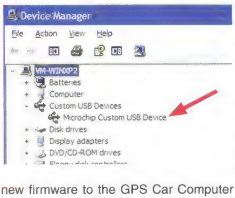
Both the device driver and software described here are compatible with Windows 2000, XP (32 and 64 bit) and Vista (32 and 64 bit). Windows 7 is not supported yet but the software does work under the Windows 7 XP Mode. There also may be Linux and Mac versions on the Internet – check the Microchip website or Google for "MCHPUSB Bootloader" or "MCHPUSB Driver".

To start the bootloader, hold down the Set button on the GPS Car Computer while you plug it into a USB port on your computer. If you have not installed a jumper on JP1 you will then have to connect an external 12V power source and hold down the Set button while you plug that in. You can release the button a second or two after.

Your computer should make a sound to signal that it has recognised the GPS Car Computer. Note that when it is in the bootloader mode the LCD panel will remain blank or may show some random lines, this is normal.

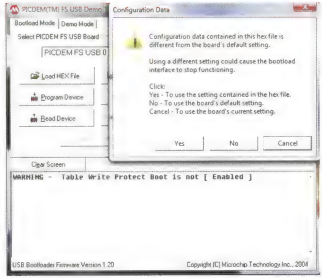
If you have not used the bootloader before on your computer you will be prompted to install a driver for it. This driver is different from the virtual serial port driver used to receive GPS data from the GPS Car Computer. Your computer may attempt to find a driver currently on your computer or the internet. When this fails select the option to choose your own driver. The device driver is in the directory WinDriver which should have been created when you unpacked the zip file containing the updated firmware. Navigate to this directory and tell Windows to search there.

When the driver is correctly installed you should see it listed in Device Manager as a "Microchip Custom USB Device".



When you unpack the upgrade zip file you should also have a directory titled WinLoader and in that directory will be PDFSUSB.exe. This is the program that uploads new firmware to the GPS Car Computer and is actually intended for use with the Microchip PICDEM FS USB board. Because of this it includes many extra features that we will not be using and can safely ignore.

Double-click on PDFSUSB.exe to run the loader. After it has loaded, you can click on the dropdown list and you should see listed PICDEM FS USB which is what the GPS Car Computer masquerades as while it is in the bootload mode. Click on that entry to select it, then click on "Load HEX File" and navigate to and select the new firmware that you want to load.

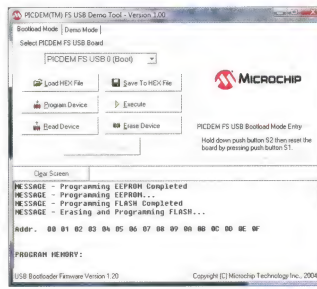


When you load the HEX file you should see a message warning that the configuration data is different from the board's default setting. Click on Cancel – do not select any other choice otherwise your firmware will not load correctly.

Finally, click on "Program Device". You will see a series of messages and after about 20 seconds it should display the messages shown in the screenshot, which indicate that the GPS Car Computer has been successfully reprogrammed. You can then unplug the GPS Car Computer and use it as you would normally do.

Don't worry about a power failure or accidently unplugging something while it is programming.

If something does goes wrong you can always restart (ie, unplug, then plug back in while holding down the Set button).



A challenge . . .

As described earlier, the GPS Car Computer has two spare input/output lines that could be used for something interesting. Do you have an idea for them? If your idea is useful and would appeal to our readers we could incorporate it into a future firmware revision. Drop us a line at silicon@siliconchip.com.au.

We cannot guarantee to implement everything as there is not a lot of space left in the micro's program memory, but it is worth a try.

The GPS Car Computer is also not restricted to cars; there could easily be a nautical version if there was sufficient interest. Even more radical, it has been suggested that it could be used as an accurate bedside alarm clock (no, not yet another GPS clock!) The various outputs could be used for timed control of your electric blanket, your radio and even turn on the kettle.

Just think of it as a general purpose device with I/O, display, USB and an optional GPS, all powered from a plug pack or 12V. Because the gadget can be re-programmed so easily there is no reason why there could not be many different versions of the firmware, each providing a different personality. Let us know, your idea could trigger something interesting.

The author has set up a web page to provide up to date errata, notes and new firmware for the GPS Car Computer. You can check it out at **http://geoffg.net/gpscomputer**.

ted on a moving satellite image of the country through which you are travelling. Isn't technology wonderful?

External connections

All external connections are made through CON1, a 6 pin mini DIN connector. Ground and 12V are on pins 3 and 4 (respectively) of the connector. An external input from the vehicle's headlight's circuit can be wired to pin 1 to control the day/night backlight brightness (more on this in the section on assembly options).

Pin 5 of the connector can be wired to a fuel injector solenoid if you want to implement the fuel economy meter function. The 82kΩ and 47kΩ resistors serve to drop the vehicle voltage levels to 5V for the microcontroller.

There are also two spare connections (pins 6 and 2) which can be connected to pins 9 and 10 of the microcontroller. These are unused and available for future use. They can be set by the firmware to be digital inputs, digital outputs or analog inputs. Future firmware updates could use these to measure voltages (eg, battery voltage or sensor outputs), detect digital inputs (eg, switch closure or tachometer output) or set them to be an output to control something.

Firmware

In Part 1 last month we described the circuit for the GPS Car Computer but it is in the firmware where the real work is done. We will not go into detail here but if you are really interested the source code is available for download from the SILICON CHIP website.

On the surface it appears that the microcontroller only needs to take the data from the GPS module and display it on the LCD and that should be simple enough. As usual, the devil is in the detail and the result was rather more complex – the firmware runs to over 7000 lines of C code.

Part of the reason for this size is that we use a graphics display and while this allow us to turn off or on any pixel, it does involve a much greater overhead to drive. For example, we have to create our own fonts - in total we use three different fonts ranging from very large numeric digits for things like the speedometer through to a small font used for detailed screens like the latitude/longitude display.

Other features including USB and high speed refresh of the graphic display also add up so that in the end the firmware uses most of the PIC18F4550's 32KB program space.

In summary the operation of the firmware is easy to explain. Firstly there are three interrupts that operate, one when a character is received from the GPS module, one that is triggered by a timer every 85μS and one when the USB interface has received or sent a packet of data.

The interrupt does just what it says – it interrupts the processor and branches to a different segment of code to do some special processing. For example, when a character is received from the GPS the interrupt code will retrieve that character and store it in memory. When the last character of a message has been received the interrupt code will set a flag to indicate that all the data has been received and is available for processing.

Following the interrupt the processor will return to executing the main program at exactly the spot from where it was interrupted. As a result the main program is unaware that the processor has been "hijacked", all it sees is that a flag has been "magically" set to indicate that there is a message from the GPS ready for processing.

Similarly the interrupt triggered by the timer every 85μS performs a number of tasks, one of which is to tell if a button has been pressed. There are three flags, one for each of the buttons and the interrupt code will set the appropriate flag when it detects a valid button press.

Oblivious to the interrupts, the main code runs in a high speed loop checking these and other flags for something to do. For example, if the main program discovers that the GPS data flag has been set, it will process the data to extract the information that we want. It will then construct an image of the currently showing screen as a bitmap in internal memory and transfer this image at high speed to the LCD's display memory.

"State Machine"

An important part of the main program is that it implements what is called a "state machine". Each display on the graphics display is represented as a "state". So, when we are displaying the digital speedometer the state machine is in the "display speed state". When adjusting the over speed setting the state machine is in the "set over speed state", and so on.

The state machine is necessary because an event like pressing the Up Button can mean different things, depending on what state the display is in. For example, when displaying the speedometer, the Up Button will cause the display to switch to the clock display but when adjusting the over-speed setting the Up Button will increase the setting by one km/h.

The state machine keeps track of the current state and changes states as necessary. It also directs processing according to the event being processed and the state that is current. Generally a state machine is at the core of most gadgets (microwave, dishwasher etc) and is not very mysterious. If you download the source code for the GPS Car Computer and search for the main() function you will see the state machine implemented in that function. SC

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02/10

A precision Temperature Logger and Controller

Part 2 – by Leonid Lerner

Last month we introduced this temperature logger and controller, based on the $99 Dick Smith Q1437 Digital Thermometer. Here are the construction, testing and setup details – along with a couple of pertinent warnings!

The first step in construction is to make and solder in the interface to the Dick Smith Q1437 Digital Thermometer. This is achieved by opening the case and wiring in a 2.5mm stereo jack socket, which in turn connects (externally) to the PC via a 2.5mm jack plug, a suitable length of shielded stereo cable and a DB25 (parallel printer port) plug.

Remove the protective rubber sleeve of the Digital Thermometer and then unscrew four screws, including the two for the battery compartment. Then gently prise the top and bottom covers apart. They will remain loosely connected by the two leads to the piezo sounder which is glued to the bottom cover.

Next, a short (~100mm) length of ribbon cable is stripped and soldered to the WR (pin 12) and data (pin 11) lines of the HT1621, with the third lead soldered to the earth as shown in the photograph and diagram. While the prototype used white, there's a lot less chance of error if "rainbow" ribbon cable is used for this.

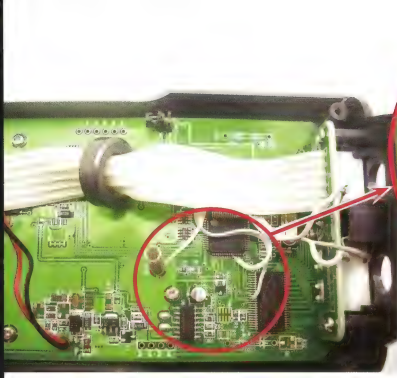
The HT1621 comes in a dual-in-line surface-mount package with pins only 0.5mm wide, so great care is required in soldering to this component. In practice, one wire is soldered to pin 11 of the HT1621 while the connection to pin 12 is made at the respective pin of the MF430F quad flat package.

End-on view of the DSE Q-1437 Digital Thermometer. The two sets of thermocouple sockets are original; the 2.5mm stereo socket is an addition to interface with this project, as described above.

Using a magnifying glass as an aid, the well-tinned end of a 1mm soldering iron tip is touched against the outer extreme of each pin to be soldered, depositing a very small bump of solder.

Now the tinned end of the ribbon cable is placed on top of the pin and compressed against it by pressure from the soldering iron tip for a few seconds so the solder flows and a connection is made. Inspect the joints carefully to ensure no shorting has occurred – use the very minimum amount of solder consistent with making a good connection.

An 8mm hole is then drilled in the top end of the case to allow fitting of the 2.5mm stereo socket, as shown below left. The



A close-up view inside the DSE Digital Thermometer with a magnified view above, showing the three connection points required, along with the new 2.5mm socket in the top of the case. Soldering to these fine IC pins is NOT easy to do – be extremely careful – a hot iron with a fine tip plus a steady hand are *de rigeur!* Inspect carefully for any solder bridges.

thermocouple connectors will have to be temporarily unscrewed from the panel to allow the new socket to be inserted.

The ribbon cable wires are then soldered to the socket while ensuring the earth lead is soldered to the correct terminal. The signal leads should be soldered to the signal pins on the socket so that the body, tip and ring (BTR) connect with the same pins on the 2.5mm plug.

In other words, pin 11 of the HT1621 goes to pin 12 of the DB25M connector to the PC while pin 12 of the HT1621 goes to pin 13 of the PC connector.

As mentioned last month, connection to the PC printer port is made by means of a 2-core shielded cable to which a 2.5mm stereo plug is connected at the Q1437 end, while a DB25 connector is soldered at the PC end. The two 680pF capacitors are soldered directly at the DB25 connector from pins 12 and 13 to the earth at pin 25.

You will also need to make the cable connection to the Triac load controller box, which we will look at shortly.

First, carefully re-assemble the Q1437 Thermometer in the reverse order to disassembly, ensuring that the added ribbon cable does not foul anywhere.

Load controller PC board

This uses a single sided PC board measuring 87 x 54mm and coded 10101101. The complete component overlay and wiring diagram (combined) is shown in Fig.3.

Assemble the PC board as shown in this diagram – there are only seven components and only the semiconductors (Triac and Triac trigger) are polarised. Do not substitute the specified insulated tab Triac for another – your safety depends on it.

Note that the legs of the Triac are "cranked" to allow them to fit into the PC board. It is a good idea to leave the Triac until last to ensure that its mounting hole lines up with the hole drilled for it in the box side.

Also ensure that the 10nF capacitor is an "X2" class for mains rating and safety. Do not substitute another type, even if it has a higher voltage rating.

Mounting the PC board

The PC board is mounted in a suitable diecast aluminium box. This will need holes cut out to accept IEC male and female chassis mount sockets, a mains safety fuse and a DB9 socket. You will also need to drill holes for the mounting for the IEC socket mounting screws, a separate earth and the single screw for the insulated tab Triac.

Check These Important Safety Points

(1) Use mains-rated hookup wire for the connections between the PC board and the DB9 connector. **These leads must be kept as short as possible and secured at both ends using Nylon cable ties.** That way, if a lead comes adrift, it cannot move and contact any mains-operated components on the PC board or the terminals of the IEC sockets. It's also a good idea to **further secure the leads at both ends using clear silicone sealant** (be sure to use a type that's acetic acid free).

(2) Use mains-rated cable for all connections to the IEC sockets and completely insulate the terminals using heatshrink tubing. Alternatively, use insulated spade lugs (you must use a ratchet-driven crimping tool to properly secure the spade lugs to the leads).

(3) Secure the high-voltage wiring between the PC board and the IEC sockets with cable ties. Again, the idea is to make it impossible for any leads to move and contact other parts of the circuit if they come adrift.

(4) Fit an extra locking nut to secure the earth solder lug in place. This nut locks the first nut into position, so that it cannot possibly come undone.

(5) Do not substitute another Triac for the specified BTA10-600B. This particular Triac has an insulated tab which means it can be fastened to the metal case with complete safety.

(6) Part of the circuitry on the PC board operates at mains potential (as do the terminals of the IEC sockets). Do not touch or work on any part of this circuitry while this device is plugged into the mains. **DO NOT attempt to build this device unless you know what you are doing and are familiar with mains voltage wiring techniques.**

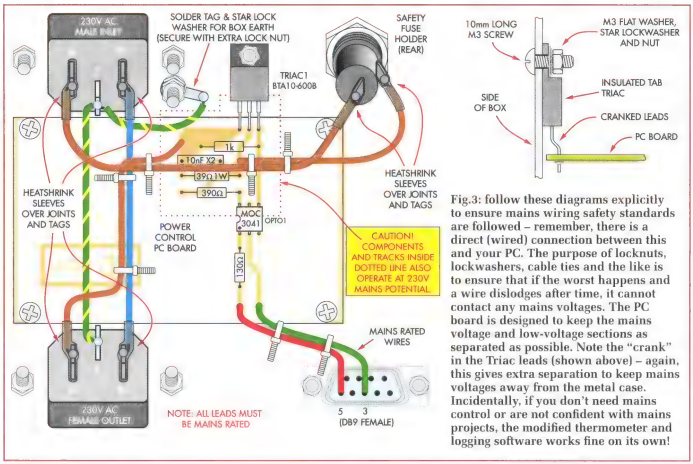


Fig.3: follow these diagrams explicitly to ensure mains wiring safety standards are followed – remember, there is a direct (wired) connection between this and your PC. The purpose of locknuts, lockwashers, cable ties and the like is to ensure that if the worst happens and a wire dislodges after time, it cannot contact any mains voltages. The PC board is designed to keep the mains voltage and low-voltage sections as separated as possible. Note the "crank" in the Triac leads (shown above) – again, this gives extra separation to keep mains voltages away from the metal case. Incidentally, if you don't need mains control or are not confident with mains projects, the modified thermometer and logging software works fine on its own!

Make sure that you follow explicitly the wiring details above. All wiring must be done with 250VAC-rated cable.

Note that the earth wiring is soldered to the earth pins of the two IEC sockets and to a separate solder lug which connects to the diecast metal case via a screw.

Not immediately obvious in the diagram is a locknut on the earth screw – a good idea to ensure that nothing can ever vibrate its way loose.

The earth plane of the PC board is not connected to the mains earth of the case. It connects to the earth of the PC via the 9-pin DB9 socket, 2-way ribbon or shielded cable and DB25 plug (the same plug which connects back to the Q1437 Digital Thermometer)

Finally two short lengths of mains-rated wire are used to make a connection between the input to the MOC3041 and PCB earth and the DB9 socket. This pin is connected externally to pin 2 of the parallel port.

Checkout time

First, we will check operation of the thermometer interface. The project software consists of two files. T_Controller.exe is the main file containing the GUI (graphical user interface), while Porttalk.sys is the system device driver carrying out the low-level port communication. The latter file needs to be copied to the /Windows/system32/drivers directory on your computer while the former can be located in any convenient folder.

Next T_controller.exe is run and the GUI screen (as shown below) should appear.

Connect the PC to the Q1437 digital thermometer and turn the thermometer on by holding the green ON button down for longer than three seconds. This ensures that the AUTO-OFF function, which turns the thermometer off after 30 minutes, is disabled.

At this stage click the Run PC Mode button at the top right of the GUI and a display indicating the time, the two temperatures, the current duty cycle of the Triac control signal and the message 'Running" should appear at the bottom of the GUI.

In addition, provided the thermocouples are plugged in to the thermometer, two curves, blue and black, should commence to be drawn out on the screen.

The temperature limits corresponding to the top and bottom of the graph, are designated in the appropriate boxes next to the vertical axis at the top and bottom of the screen, while the times are indicated in the corresponding boxes next to the horizontal axis.

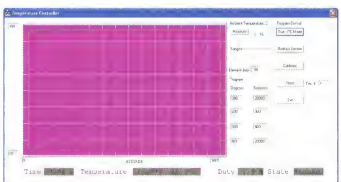


Fig.4: here's the GUI screen which you should see after running the T_controller.exe software .

If it is desired to rescale or reposition the graph, these values can be changed during the acquisition while the curves are being drawn and the 'Redraw' button pressed.

Once sufficient data has been gathered the 'Abort' button can be pressed. Acquisition then ceases and the temperature data gathered so far is saved in a text file labelled Tdata#.txt, with # being the number label entered in the edit box next to the 'Abort' button.

A new acquisition can be started afresh at any stage now by pressing the 'Run PC Mode' button, however if the file label has not been changed when 'Abort' is next pressed, the data from the previous run will be overwritten.

The data in the text file is presented in the form of two vertical columns corresponding to the two temperature channels at one-second intervals. The temperatures are presented as the actual temperature in degrees times 10 to allow representation of the decimal component of the measurement using whole numbers.

Should the Q1437 be turned off or the interface disconnected at any stage, the PC will reach a point where it tries to read the Q1437 and 'hang' due to lack of data on the line. It will commence functioning properly again once the connection with the Q1437 has been re-established. To switch the logger off, either the 'Abort' or 'Exit' buttons should be pressed before turning off the Q1437.

Starting the Triac load controller

A mains load can now be connected to the Triac load controller. Use a load which will give a direct indication of duty cycle, such as a heat gun (which you will hear changing as the duty cycle changes) or a large incandescent lamp.

The mains plug is now attached to the controller and with the cable to the PC disconnected, no power should flow to the load. The control cable from the PC parallel port is now attached and a representative duty figure, such as 50%, entered into the GUI.

A temperature higher than ambient with a duration greater than zero is entered into the respective GUI boxes. Upon pressing the 'Run PC Mode' button the load should start to be pulse at about a 1:1 mark to space ratio, ie, half second on, half second off.

If the unit passed all the above tests it is ready to be used as a temperature logger and controller. Just enter the time (in seconds) and temperature (in degrees) with the requisite number of set points (up to four) in the temperature program box, and press 'Run PC mode'.

If during the course of data logging it is desired to investigate the graph being produced over a different range of time and/or temperature values than initially chosen, new values are entered into the corresponding boxes, and the 'Redraw' button pressed to replot the graph.

In the same fashion the temperature program can be altered 'on the run', with new set points reflected by changing locations of the horizontal set temperature lines on the graph.

When the 'Abort' button is pressed all data logged so far will be recorded and can be inspected with Wordpad, imported into a spreadsheet, etc.

Finally, if you are not confident of constructing mains projects, or even if you just want a temperature logger, you can simply do the mods to the thermometer and it will function perfectly as a stand-alone device (ie, without the Triac load controller attached). SC

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The old Mullard Meteor 600 cleaned up quite well, as is evident from these above-chassis views. The parts on the top of the chassis are easy to access.

using a Philips-type fixed-wire trimmer. Once adjusted, it was expected to retain its tuning almost indefinitely although this doesn't always work out in practice as we shall see.

Both the antenna coil and the oscillator coil are housed in the same metal can, located on the back edge of the chassis. This is convenient for access but means that both would have to be replaced if a fault developed in either section.

The signal from V1 is applied via the tuned circuit to V2, an EBF35 IF (intermediate frequency) amplifier. Bias is applied to both V2 and V1 via resistors R5 and R15. R14 and C23 act as a filter for any hum that may be on the back bias line, which consists of R7, R4 and R3. R4 varies this bias from -1.2V up to -26V.

At -26V, the EBF35 will still have some gain, as its plate current is not cut off until the bias reaches around -38V. However, the ECH35 will be cut off, as its cut-off voltage is -17V, so effectively the volume will be zero even before the volume control is at its minimum setting.

V2 amplifies the 455kHz signal and this is applied to the IF transformer which consists of L6, L7, C13 and C16. The output of this transformer is then applied to the detector diodes in V2 and the detected audio signal is developed across resistor R6. The signal is then coupled to the grid of V3 (6V6GT) and this stage then drives the speaker transformer and a 5-inch (125mm) speaker.

Bias for the 6V6GT is obtained from another back-bias voltage divider consisting of resistors R8 and R12. This divider supplies -5.5V to the grid of the 6V6GT.

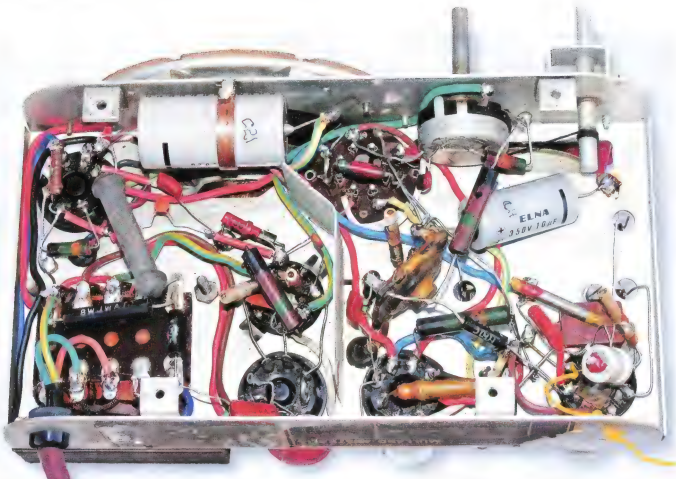
Power for the receiver is derived via a mains transformer which has a tapped primary to suit mains voltages between 220V and 260V AC (40-60Hz). In the service notes, there is a comment that the transformer lamination stack may be one inch (25.4mm) or 1.5 inches (38mm) high. I believe that for 40Hz mains, the stack would have been 1.5 inches high. The transformer in this particular set is designed for 50Hz and 60Hz mains, as it only has a one-inch high lamination stack.

The HT secondary winding of the transformer drives a 6X5GT rectifier (V4) and the filter capacitors have common positive terminals, while the filtering resistors are wired into the negative supply line and consist of R8 and R12.

Back bias

The voltage drop across the back bias line of R8 and R12 is around 75V. I question why such a high voltage is dropped across the network. It seems to me that more effective use of the available high-tension (HT) voltage could have been made. The voltage across C17 is of the order of 185V and with 75V dropped across the back bias network, only 110V is available for the valves. The total HT current drain is around 28 milliamps.

6V6GT valves really don't work all that well until they have 150V or more on their plate and screen elements. By reducing the voltage drop across the back bias network and re-jigging the power supply circuit, around 150V could have been supplied to the 6V6GT. This could have been obtained without changing the power transformer or many other small parts.



This under-chassis view shows the set before it was rewired. Note the incorrect use of green/yellow mains earth wire for some of the connections (this wiring was later replaced).

Because of the low HT voltage, the audio output is quite limited and it becomes distorted if pressed hard on strong stations.

Restoration

The owner of this set kindly loaned it to me so that I could complete the restoration and write this article. When he bought it, it had largely been restored. However, a common problem is that although sets are often advertised as having been restored, the restoration is often not complete or has not been done correctly. Such was the case with this radio.

As mentioned earlier, the set is easily removed from the cabinet and the works readily accessed. The cabinet is in good condition and required no attention from me. However, a quick look at the chassis showed that the frequency converter had been changed, along with the paper and electrolytic capacitors. The wiring had also been changed.

The chassis layout should have been better that it is. In some cases, the inputs and outputs are close together and this has made it necessary to fit a metal shield in the centre of the chassis to ensure stability. The coils connected to the converter valve are located quite some distance apart too. In addition, placing the rectifier valve next to the IF/detector valve is just asking for hum to show up in the audio output.

In fact, the audio coupling capacitor is only 1nF, which does indeed suggest there was a problem with hum in the audio. By using a low-value capacitor here, the low-frequency output is restricted, reducing the hum problem in the process.

Only one lead of the original wiring was left in the set. That was the earth lead and the insulation on it had perished. No doubt, the previous restorer had replaced the wiring because the insulation had perished.

Although the replacement wiring had been installed neatly, the type of wire used was incorrect. In particular, scraps of mains wire had been used in various places, including green/yellow mains wire. The latter should only be used for mains earth wiring.

As a result, much of the wiring was redone, not only to conform to the necessary standards but also to make the restoration look more original.

The replacement capacitors had all been wired in correctly and the two replacement electrolytic capacitors even had C17 and C21 marked on them. However, they had been transposed in the circuit, which could prove confusing. **There was no sign of the mains antenna capacitor, which I would have removed anyway for safety reasons.**

Finally, the original 2-core mains lead had been replaced with a 3-core lead and the chassis earthed. However, this lead had not been anchored correctly and so had to be secured using a cordgrip grommet.

Does it work?

Everything else appeared to be in good order so the next step was to test the mains transformer with a high-voltage insulation tester. This showed no signs of excessive leakage between its windings or to the chassis, so it was now time to try the set out.

The first step was to apply power

This photo shows the three trimmer capacitors around the oscillator & antenna coils. Two are semi-fixed tubular types while the third is a Philips "beehive" type.

The first 455kHz IF tuned circuit consists of coil L5 & its parallel semi-fixed trimmer C10.

with the chassis resting upside down and check the voltages at various points in the circuit. These were all found to be quite close to those listed in the service sheet and the power consumption was a quite reasonable 24W. I then connected an external antenna to the set but found that the performance was nothing to get excited about.

I tried replacing the EBF35 IF amplifier and the 6V6GT audio output valves but this made no difference. I didn't try changing the ECH35 converter, as it appeared to be new.

So what was causing the performance of the receiver to be so poor? The voltages were close to what they should be, the necessary capacitors had been replaced and the defective wiring had been replaced.

This set (and some Philips sets) uses custom-made semi-fixed capacitors which act as trimmers in the tuned circuits. A couple of these trimmers can be seen in the photo of the oscillator/antenna coil assembly, with one towards the top of the picture. It consists of a thick wire inside a ceramic tube, with many turns of fine wire on the outside of the tube. The number of turns of wire wound on the ceramic tube determines the capacitor's value.

To adjust these trimmers (or semi-fixed capacitors), it is necessary to initially wind on more turns than required, then gradually remove turns until the circuit is tuned to the correct frequency (it's too bad if you take too many turns off). This set has five of these trimmers and the only trimmer not of this type is C9 which is a Philips beehive-type trimmer.

As mentioned previously, the semi-fixed capacitors are meant to retain their values and supposedly never need readjustment after the set leaves the factory. However, that was wishful thinking as some certainly needed tweaking in this set and they are difficult to deal with.

The previous restorer had decided to leave these "one-time" adjustable trimmers well alone. However, I decided I just had to bite the bullet and adjust some of them to improve the set's lacklustre performance. They are hard to adjust and **extreme care is needed when doing this as two of them operate at the HT voltage!** However, it needed to be done if the set was to operate correctly.

First, I adjusted C9 so that the set tuned to the local Italian station on 1629kHz, then checked the alignment of the IF stage.

The circuit seemed to be roughly tuned to 455kHz but the response to nearby frequencies was greater than expected, indicating that the IF stage needed alignment. I assumed that the capacitors had been adjusted correctly when the set was made so to make the adjustments a bit easier, I placed small 10pF mica capacitors across each tuned winding. I then set the signal generator to 455kHz and gradually removed turns of wire from each trimmer until the peak response had just been reached and was beginning to dip again.

When I went too far, I just rewound several of the turns back onto the ceramic tube and glued them in place. It's not a very elegant method but it works.

Because both C10 and C16 are live to around 110V (with respect to the chassis), extreme care is needed to ensure that nothing shorts when pulling the wire off to adjust these trimmers. And although I thought I was being careful, I wasn't careful enough and did get a "bite" off the 110V.

In retrospect I should have worn rubber gloves when doing this task and I certainly will in future. So be warned – even experienced people can make mistakes. Unfortunately though, these adjustments cannot be made with the

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set turned off otherwise I would have done it that way.

After making these adjustments, the set's performance was considerably enhanced and it performs quite well local stations.

Summary

The Mullard Meteor 600, despite no having outstanding RF or audio performance, is quite a reasonable little receiver for use in the kitchen or bedroom. It is housed in a relatively small bakelite cabinet but the components are not so crowded that service is difficult.

However, the layout of the components leaves a lot to be desired and the electronic design is deficient in a number of areas as well. For example, the set could have used AGC (automatic gain control), as the two RF valves are variable mu types. It is not that it would have required extra components.

In addition, the HT could have been made as high as 150V which would have meant that all valves operated with improved performance, especially the 6V6GT audio output stage. This could have been achieved with only relatively minor changes to the values of a few low-cost components.

It all goes to show that some makers got away with some very ordinary design and layout techniques but only because the sets were budget models and were not required to be high performers. However, this set could have been a good performer without adding to the cost.

That said, it's a nice-looking set and if its limitations are accepted it is a worthwhile receiver to have in a collection.

Finally, as a reflection on design, I was involved in the testing of new 2-way radios for a government department prior to them being approved for use by industry. During this work, it soon became obvious that some designers really knew how to design and build good 2-way radios while others produced radios that were very ordinary.

I distinctly remember two transceivers I had to test from different manufacturers. One barely met the test criteria and disappeared from use within a few years, while the other was so good that it is still used by some services some 35 years later. The same thing has happened in the design and construction of domestic valve radios – the large manufacturers didn't always get it right, while many small manufacturers produced excellent equipment.

Basically, a lot depended on who the designer was at the time when it came to the quality and performance of a receiver. SC

Photo Gallery: Tasma 585 Mantel Radio

The Tasma 585 was a large-size mantel radio, with a vibrator power supply pack nearly half the size of the radio itself and powered by a 6V accumulator. The valve line-up was as follows: IM5G RF stage, IC7G mixer, IM5G IF amplifier, IK7G detector/first audio amplifier and IL5G audio output. The intermediate frequency (IF) was 458kHz. Features included dual-wave tuning, a permanent magnet speaker and a handsome wooden case. Photo by Kevin Poulter for the Historical Radio Society of Australia (HRSA). Phone (03) 9539 1117. www.hrsa.net.au

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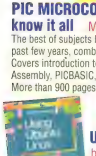

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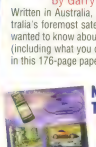

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by Sanjaya Maniktala. Published 2006.

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by Malcolm Barnes. 1st Ed, Feb 2003.

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RF CIRCUIT DESIGN

by Chris Bowick, Second Edition, 2008.

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Is it legal to do off-grid electrical wiring?

I just found your article on DIY home wiring from several years ago. Is it still OK in Queensland to do your own wiring if you are on generator power and not connected to the grid? Also, are there any good DIY books on the subject for Australian homes as I can only find English or US ones? B. C., Emu Creek, Qld).

● You cannot legally do your own wiring in Queensland or in any Australian state. This is despite the fact that it is perfectly legal in New Zealand where they use exactly the same wiring standards (ie, AS/NZS3000:2007) and the same electrical fittings. You can check the full details of what is possible in New Zealand in our article entitled "Are Aussies Dumber Than Kiwis?" in the June 2008 issue.

As far as off-grid systems are concerned, if you are installing any solar system with the intention of claiming government rebates, again you need it installed by a licensed electrician.

There are additional wiring standards for electrical systems that are off the grid and safety is a major concern. The relevant standards are:

(1) AS 4509: Standalone Power Systems (presently under revision).
(2) AS 4086: Secondary Batteries.
(3) AS 4777: Grid-Connected Inverters (not applicable in your case).
(4) AS1768: Lightning Protection.

We recommend the book "Solar Success – Getting It Right Every Time" by Collyn Rivers. It is available from the SILICON CHIP Bookshop for $47.50 plus $10 postage & packing.

Connecting VU meters to an audio amplifier

I have built an audio power amplifier kit from Altronics and I bought a couple of VU meters. I want to use them as power meters; just to show percentage – not accurate.

Can you please tell me how to connect them to the amplifier outputs without influencing speaker impedance? The meters are not proper VU types, just DC milliameters. (J. S., via email).

● VU meters show a 0VU reading when the applied voltage is 1.23V RMS. To show power output from an amplifier, the voltage from the amplifier would need to be reduced before it is applied to the VU meter. Typically an amplifier output would need to be reduced by about a factor of five for the VU meter.

Ideally, the VU meter should be driven from a low impedance source to ensure it has the correct attack and decay response rate. For your application where it is just as a display, a series resistor of around 3.3kΩ (1W rating) from the amplifier output to the meter should be suitable. The meter connection will not affect the actual power applied to the loudspeakers.

The value can be reduced if the meter does not not show the full range you require.

This is assuming you are using Altronics VU meters (Cat. Q0490) that have a 650-ohm resistance. A VU meter is an AC meter with a predefined attack and decay response. A DC milliameter cannot be used directly as a VU meter since it would require a full wave rectifier, filter and meter drive circuitry.

Programmable Ignition For BMW 2002

My brother and I have built the Programmable Ignition (SILICON CHIP, March, April & May 2007) from a Jaycar kit for his BMW 2002. We have a reluctor distributor from a later model car and adapted it to fit. The winding reads just under 1000Ω and on a test unit, it generates -1V to +1V at 1000 RPM.

We have tried to follow the procedure to set VR1. It reads 4.98V regardless of the VR1 setting. I have unsoldered VR1 and confirmed that it does cover the 0-100kΩ range. I assume the the reluctor should be connected when doing the settings?

In this set-up, it seems the Q5's output never gets to 0V. Do we need to change some of the resistor values to match the output range of this reluctor?

We have managed to get it running (badly) on points with a zero map (using the original clockwork weights) but are getting some sort of interference. I've mounted the ignition driver module in the same box, so now are going to move that to its own box to attempt to eliminate the issue. (R. W., via email).

● The reluctor may be faulty as a -1V to +1V signal is very low. Try adjusting the reluctor gap so there is more signal.

You may be able to improve the reluctor triggering by removing VR1 and decreasing the 47kΩ resistor at the base of Q5 to 10kΩ.

Smoke gets in your eyes

I have just finished constructing the Power Tool Battery Charger Controller (SILICON CHIP, December 2006) and having some knowledge of electronics over the years, fixing minor faults on TVs, VCRs etc, I was confident of tackling this project.

I was able to set 5V between TP5 & ground and had 5V between pin 14 & pin 5 of IC1's socket. I installed IC1 and all was good when I connected a battery to the controller but when I connected the thermistor cable from the battery (the tip of the plug touched socket earth), part of the copper track on the circuit board burnt out, with smoke coming from the 10Ω resistor.

I think I might have wired the thermistor wrongly (haven't had anything to do with these before) as there is no detail in the instructions about how to wire it into the battery. I had it con-

nected across ± terminals. Should that have been across the mono socket? This may have damaged IC1 because when I turned it back on after repairing the copper track smoke still came off the 10Ω resister. When I removed IC1, it powered up OK with the right voltages. Any help will be appreciated. (R. C., via email).

● The thermistor should be completely electrically isolated from the battery and not connected across the battery terminals. The thermistor is there to monitor temperature and is mounted against a cell in the battery pack but needs to be electrically isolated from the battery terminals and any exposed metal part of the battery. The thermistor installation was detailed under the "Connection" sub-heading in the article.

The main IC could have been damaged (depending on battery voltage) when the battery plus via the thermistor connection was connected to the thermistor input. A replacement IC for the charger controller can be obtained from Jaycar Electronics.

Memory constraints in battery capacity meter

I have built the Battery Capacity Meter featured in the June 2009 issue. The data logging only gives me a 12Kb CSV file, with data for the last three hours only. I can't find any information in your article on the size of the data memory.

Can you please advise what this is? I realise that the RLE compression can be changed to save more data but I want weeks of data, not a few hours. Is there any way to extend the amount of stored data or to add additional memory? (N. N., via email).

● The Battery Capacity Meter stores logged samples in RAM which is quite limited. The actual RAM used for data logging can hold up to 116 samples. This may not seem much but they are RLE samples. Each such sample can hold 16,380 actual samples, depending on the RLE compression used.

If you would like weeks of data, you will need to vary the sampling period – make this longer. Also you may want to modify the RLE compression. For example, if you changed the sampling period to 7200 seconds, then an entry will be logged every two hours.

With 116 samples, at worst case (without any RLE compression) you can get a total logging time of 835,200 seconds or over nine days of data. With RLE compression this could be much longer. It is simply a compromise between sampling period, level of compression and total log time.

With RLE compression you can of course achieve much better rates. Since the logging quantities are not changing wildly over time but in a continuous manner, it makes sense to use compression. It is a compromise between logging time and accuracy.

There is no easy way to add extra memory – the design was simply not made for that. The other option is to download data more frequently. If you downloaded data every day, you could change the sampling period to 750 seconds (or one entry every 12 minutes or so). In the worst case without RLE compression, it would take about a day for the memory to fill.

Note that you can also change whether the buffer works in Capture or Overwrite mode. In overwrite mode, new logging data overwrites older data – the effect is that only the last samples are kept. In capture mode, however, the buffer accepts no more data once it is full.

FM Micromitter Has Fixed Output Frequencies

I have an FM Stereo Micromitter kit (SILICON CHIP, December 2002) that I would like to change the frequency from what your ranges are. We have a gentleman in our church that uses a Tx/Rx that works on 91MHz as a hearing aid unit.

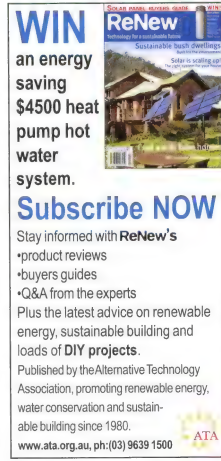
Is it possible to change the output so it will work on this frequency? It would make listening for him much better if we could have a set-up from our PA system, whereby he can listen without having to transfer his Tx unit over to each person that speaks and also eliminate the noise created during this time.

He can alter the frequency slightly if necessary but this would involve several other changes to other equipment if we need to do this. (D. W., via email).

● The short answer is no. The long answer is that the FM stereo micromitter has a phase lock loop RF oscillator that provides fixed transmission frequencies between 87.7-88.9MHz and 106.7-107.9MHz, as specified in the article. There is no easy way to change these frequency ranges without affecting the 38kHz oscillation for stereo multiplex operation. So a simple change of crystal frequency is not a solution.

A specially cut crystal running at 7.77953MHz would allow the 88.9MHz setting to operate at 91MHz. This will shift the 38kHz and 19kHz pilot tone to 38.9kHz and 19.45kHz respectively and may affect the stereo operation but it will still operate in mono. Specially cut crystals can be obtained from Hy-Q Crystals – **http://www.hy-q.com.au/specdrawings.htm#tCrystals**

The QC49/S type would be suitable. An alternative solution would be to buy an FM transmitter designed to transmit from an MP3 player. These are available from Dick Smith Electronics, such as the Belkin XH-8217 and C9950. There is also the C5810. They appear to be settable to any FM frequency but check that they can be set to 91MHz.



Ignition For Old Mercury Outboard Motor

I have a 1969 in-line 6-cylinder, 2-stroke, 125 HP Mercury outboard motor. A friend and I have rebuilt the motor. The original ignition system is a CDI with a complex mechanical spark advance mechanism which is worn badly and difficult to impossible to replace or satisfactorily repair. I wish to bypass it using the Programmable Ignition Module (PIM) if possible. However, there are a some issues that make it unclear to me whether or not the PIM is suitable.

There is an unusual trigger system inside the distributor. It is described in the workshop manual as follows: "The trigger which is in the distributor comprises a rotor (appears to be iron) disk with six evenly placed windows or slots cut in it; one for each cylinder. There are two "opposite facing coils . . . one produces a magnetic field and the opposite coil produces a trigger signal when a slot passes". The trigger operates an SCR which discharges a capacitor into the primary coil. It produces a very impressive spark into centre pin only spark-plugs.

I am uncertain whether this is a Hall Effect sensor, a reluctor or some proprietary Mercury device. It has three leads – one is definitely a trigger sensor which is also run to the tachometer. There doesn't appear to be anyone alive who knows exactly what the trigger system principle is. Even some mechanics I have managed to find who once worked on these engines, glaze over on this point.

There is no vacuum advance mechanism. Advance or retard is accomplished by rotating the trigger coils in relation to the rotor disk openings (slots); this is the mechanical part I wish to by-pass. There are three synchronised side-draft carburettors and the mechanical advance/retard is directly linked to the degree of throttle opening. As far as I can tell, this means there is basically only one value of advance/retard value for any given throttle setting. The spark appears to advance to a maximum of around 38-40° and is then retarded back to 34° at wide open throttle.

However, it appears possible to install a vacuum line as there is a hose network on the outside of the motor which links the manifold areas of the three carburettors. It appears this network is for pressure equalisation for what would otherwise be three pressure isolated intake chambers within the engine block.

My current plan is to get the motor running with a Commodore MAP sensor installed in the pressure equalisation line and measure the response at various throttle/load settings, eg, with a lot of weight on board and towing a skier/drogue, etc versus minimum weight etc. Then remove most of the old mechanical advance mechanisms, fix the distributor so that it can't rotate, run an accelerator cable directly from the carburettor spindle, then add and program the ignition module using the trigger sensor as input.

So is the PIM suitable for this type of engine? If so, any idea of which of the six options for the PIM is suitable for this situation or what test I might run to find out? All I have is a basic multimeter but I might be able to hunt up some other test equipment at a pinch. At the moment I am leaning towards a Hall Effect device but the use of the word "coil" in the description of the mechanism makes me uncertain what it is. (L. S., via email).

● Given that the motor was made in 1969, it is doubtful that the sensor is a Hall Effect type, especially in view of the mechanical spark advance mechanism which is being used. That being the case, it appears that a coil system is being used and possibly it is a reluctor set-up. You can check if it is a coil as the resistance across the two wires would be low, say less than 200Ω.

There does not seem to be any reason why you cannot use the Programmable Ignition system on the motor. The reluctor version would probably be the most suitable.

12AX7 valve preamplifier

I have had a 12AX7 Valve Audio Preamplifier kit (SILICON CHIP, November 2003) sitting in my drawer for a few years and recently assembled it. I can't seem to get the 100kΩ trimpot VR1 to adjust the DC voltage down to 260V; it tends to hover around 380V.

When I plug it into an amplifier it crackles heaps. On the circuit diagram, VR1 has one leg that goes to a 220kΩ resistor, one leg that goes straight to earth and the variable leg also goes to earth. I gather this is so the DC voltage can be regulated.

On the parts overlay diagram however, it appears that the two legs of VR1 that go to earth on the circuit diagram directly are actually passing through a 47kΩ resistor. Am I misunderstanding something or is there a known error? If so, how do I fix it? (M. R., via email).

● Although there is a small discrepancy between the schematic and board overlay diagrams for the power supply section of the 12AX7 preamp, this is only "cosmetic" in the sense that because trimpot VR1 and the 200kΩ resistor are connected in series, they have the same total resistance whether the 200kΩ resistor is connected to the "top" end of VR1 or to the bottom end.

Hence, there is no known error in the power supply circuit which would prevent the converter's output voltage from being adjusted. However you are correct in judging that there is a problem associated with the feedback circuit somewhere, if your converter's output voltage remains "hovering" at around 380V and cannot be adjusted using VR1.

To track down where the problem lies, measure the voltage at pin 1 of IC1, relative to pin 7 (PC board ground). If the feedback circuit is operating correctly but the comparator inside IC1 is not, this voltage will probably be about 7-7.5V and should vary as VR1 is adjusted. This would suggest that IC1 is in some way damaged.

On the other hand, if the voltage between pin 1 and pin 7 is close to zero and does not vary when VR1 is adjusted, this would suggest that the problem is in the feedback circuit itself. You may have a faulty solder joint on one of the 680kΩ 1W divider

resistors (or at one end of the 47kΩ or 220kΩ resistors, or on VR1 itself) or a tiny crack in one of the PC board tracks linking the high-voltage DC output at the cathode of D2 back to pin 1 of IC1, ie, via the 680kΩ 1W resistors.

When you do find and fix the fault and the converter is operating correctly, you should be able to measure a voltage close to +5V at pin 1 of IC1.

Energy required to make solar panels

It takes a certain amount of energy in kilowatt-hours to create a solar panel. My question is, is the solar panel ever going to supply more energy than went into making it? And if a person is reasonably conscientious about how they look after a solar panel array, what ultimately determines its useful life? (I. T., Blacktown, NSW).

● This question of whether solar panels cost more in energy to produce than they ever deliver in their life has often been raised by environmentalists. The answer is that they do deliver more energy but it may take several years or more. In fact, the energy cost of solar panels is partly reflected in their high price. However, they are really no more expensive to produce than other semiconductors.

If you think about the bulk prices of semiconductors, they are still relatively expensive when you consider the "area" of each individual device, eg, a microprocessor or memory chip.

Solar panels do last a very long time. We would expect them to last at least 30 years. Ultimately, the failure of a panel is more likely to be due to corrosion and fatigue of the frame, hail or storm damage, etc. If you calculate the amount of energy delivered by a solar panel over this period, it will be far larger than the original production input.

Troubleshooting the inductance meter

I assembled the Inductance Meter (Silicon Chip, February & March 2005) and loaded the firmware, Flash and EPROM but the LCD shows gray blocks, the same as without the program loaded.

Do you have any procedure to troubleshoot this board? (C. H., Coral Gables, Florida).

● Our biggest concern is that, being overseas, you would not have access to the Dick Smith LCD part quoted in the article and would have used some, not necessarily compatible, alternative.

We presume the Flash and EPROM not only loaded but also verified OK. This being the case, the first issue is whether the LCD panel used is the same as that specified in the article, ie, DSE Cat Z- 4170.

Display panels, even if they use the 16x2 character format, are not necessarily compatible due to different command formats. Even if the display driver, the KS0066, is the same there could be subtle differences in the way the board is wired.

The Z-4170 is still available from DSE and can be ordered via their website: **www.dicksmith.com.au**

If the LCD module is indeed a DSE Z-4170 and the program loads and verifies OK, a faulty connection either on the PC board or between the LCD and board must be suspected. With the power off, check for connection between pins 4, 5, 6, 11, 12, 13 &14 on the LCD module and corresponding pins 19, 18, 14, 11, 15, 16 &, 17 on the AT90S2313.

If these are OK, check for +5V on pin 2 of the LCD and 0V at pin 1. Check that pin 3 is in the range 2-4V.

If all is well, check that pin 1 of the microcontroller is high. Check also that a 10MHz clock signal is present on pin 5 and that pin 4 is floating us-

. . . continued on page 103

Notes & Errata

High-Quality Stereo DAC, September-November 2009: although not critical, the 6.8kΩ resistor connected to pin 22 of IC3 (DIR9001) should be changed to 680Ω. This change affects both the circuit diagram (Fig.2) in the September 2009 issue and the parts layout diagram (Fig.5) in October 2009 (the resistor is just to the left of IC3).

Balanced Output Board For The Stereo DAC, January 2010: pins 1 & 2 of the XLR sockets are shown transposed on the circuit diagram (Fig.1, page 43). The PC board and the parts layout diagram (Fig.2, page 44) are correct.

Note also that phantom power should not be applied to the XLR sockets of the Balanced Output Board (ie, phantom power should be switched off). Alternatively, cut the tracks between the 100Ω resistors and the XLR sockets and install 10μF bipolar (BP) electrolytic capacitors across the gaps (ie, in series with the pin 2 & pin 3 outputs).

WARNING!

Silicon Chip magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of Silicon Chip magazine.

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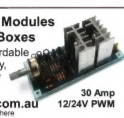

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Circuit Clarification For 12V Lighting Controller

I must congratulate Jim Rowe on producing yet another very interesting article, namely the Emergency 12V Lighting Controller (SILICON CHIP, January 2008). I have studied his design, as usual, in quite some depth and I have a query about the description in the text of how it works in the section entitled "Power Failure".

You say that the 555 IC output is set as a result of the positive going transition of pin 2 as it crosses the 4V threshold a short time after pin 4 goes high, the delay being caused by the 2.2µF capacitor. However, I hope you will not mind me saying that I do not believe this to be the case. I believe pin 3 goes high immediately when pin 4 goes high, a result of pin 2 simultaneously being taken below the lower comparator 4V threshold.

I believe that a 555 output is set on the negative-going transition of pin 2 (Trigger) as in the classic monostable and astable configurations. I believe that the positive-going transition of pin 2 has no effect on the pin 3 output. The only effect of this positive-going transition is to release the flipflop so that it can be reset on the positive-going transition of pin 6 (Threshold) as it crosses the 8V threshold, as in the case of a low battery voltage condition.

So in fact the 2.2µF capacitor holds the Trigger input (Pin 2) low for a short time to ensure a good set of the 555 output before letting it (pin 2) go high, therefore ensuring the circuit functions correctly.

I hope you don't mind me pointing out the above and I hope you'll appreciate receiving some positive reader feedback! I would be pleased to receive a response with an opinion on my analysis of the above aspect of your circuit. Keep up the good work. (C. H., via email).

- You are quite correct in your analysis of the mechanism by which the 555 is switched into the set state when the mains power fails. The switch-on of the 555 occurs as soon as the voltage at its lower comparator input (pin 2) is pulled below about 4V, by Q2 conducting due to the charging of the 2.2µF capacitor.

. . . continued from page 101

ing an oscilloscope of at least 10MHz bandwidth with the probe set to high impedance.

If all the above are OK, then either the LCD panel or the microcontroller is faulty and should be replaced.

Detecting low-repetition pulses

I want to build the 50MHz Frequency Counter published in the February 2007 issue of SILICON CHIP. Will the frequency counter pick up monostable pulses from digital projects? Secondly, what is the voltage rating at the input of the project, eg, will it measure 6V? The two input protection diodes conduct above 600mv. (R. M., Auckland, NZ).

- The frequency meter will detect a pulse train but the repetition rate of the pulses must be higher than the minimum frequency of 0.1Hz. It cannot detect monostable pulses that occur at a low frequency or only occasionally.

The input voltage can be up to +50V and -50V so this would suit a digital circuit. When the diodes clamp the voltage, the input is still via a 100kΩ resistor and parallel 22pF capacitor. This would minimise loading of the digital circuit.

Improving the digital audio oscillator

I am interested in building the Digital Audio Oscillator featured in the June 2009 issue. Would it be possible to better the THD+N performance by changing op amp IC2 to a better quality device?

- There would be no improvement. The THD of the oscillator is set by the microcontroller and its ladder network and this quite a lot higher than even general purpose op amps. SC

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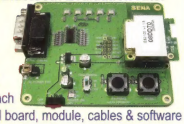

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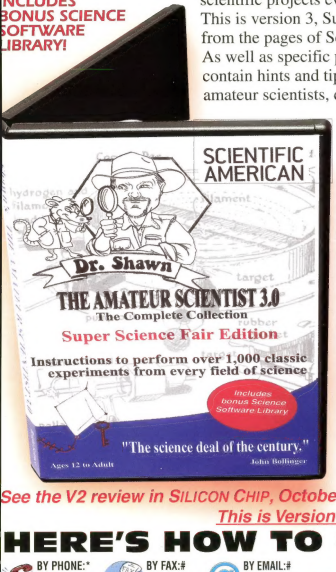

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